LOUISIANA

Indicators of Climate Change

Prepared by the

Occupational Health and Injury Surveillance Program

Section of Environmental Epidemiology and Toxicology

Office of Public Health

Louisiana Department of Health & Hospitals

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Contents

Introduction:

Climate change poses a significant threat to Louisiana due to impact of rising sea levels, increased temperatures, and extreme weather events such as hurricanes. These changes may result in injuries and fatalities related to severe weather events and heat waves; infectious diseases related to changes in vector biology, water, and food contamination; allergic symptoms related to increased allergen production; and respiratory and cardiovascular disease related to worsening air pollution.

Public health plays an important role in tracking and responding to these population health impacts, and promoting mitigating activities to reduce greenhouse gas emissions (e.g., active transportation, energy conservation). Recognizing that robust surveillance systems are needed to track climate-sensitive health events and other measures, in 2004 the Council of State and Territorial Epidemiologists (CSTE) established the State Environmental Health Indicators Collaborative (SEHIC) Climate Change Subcommittee to create a suite of indicators to allow health departments to measure current vulnerability to climate variability and change at the state and community level. Indicators included measures from 5 categories: Environmental, Health Outcome, Mitigation, Adaptation, and Policy.

In 2015, staff from the Occupational Health and Injury Surveillance Program in Louisiana (LOHIS) and a graduate intern from Tulane University School of Public Health calculated 9 of 14 Environmental, Health Outcome, and Mitigation indicators. Indicators were chosen for inclusion if there were available data. Included in this report is a summary description of each indicator plus data for the most recent available years, and historical data for the past 25 years.

This indicator process represents an important first step in developing a public health response as indicators can be used to assess human vulnerability to climate change; identify areas for intervention and prevention; and serve as an important communication tool to educate and inform various stakeholders about local climate change concerns.

Environmental Indicators:

Greenhouse gas emissions

If left unchecked, greenhouse gas emissions are expected to have significant effects on Earth's ecosystems as well as public health. The emission of greenhouse gases such as carbon dioxide (CO_2), methane, and nitrous oxide, contribute to global warming, and are largely due to human activities (Council of State and Territorial Epidemiologists, 2013a). The U.S. Environmental Protection Agency (EPA) tracks trends in CO_2 emissions as well as other gases to monitor progress in reducing global warming (Council of State and Territorial Epidemiologists, 2013a).

For years 1990-2013, CO_2-equivalent emissions were collected by the EPA. For any quantity and type of greenhouse gas, the CO_2-equivalent represents the amount of CO_2 which would have the same global warming impact. CO_2-equivalents are useful because they allow for amounts of several different kinds of greenhouse gases to be expressed as one number, and it allows greenhouse gases to be easily compared in terms of their total global warming impact (Brander, 2012). Data for Louisiana are summarized in Figures 1-7. Figure 1 displays the CO_2-equivalent emissions from fossil fuel combustion for all sectors combined as well as individual sectors. Figures 2 displays data for all sectors combined and Figures 3-7 display data for each sector.

The annual average CO_2-equivalent emissions for all sectors over the 24-year period was 212.89 million metric tons (min: 191.76; max: 233.11, data not shown), or 48.10 metric tons per capita (min: 42.71; max: 52.73). The industrial sector contributed the most with an average of 26.28 metric tons CO_2-equivalents per capita (min: 23.01; max: 29.82), and commercial the least with 0.43 metric tons per capita (min: 0.34; max: 0.61). The Mann-Kendall test for trend was performed. There was a significant downward trend in CO_2-equivalent emissions from all sectors combined ($\tau=-0.39$, $p=0.007$). Individual sectors that had significant downward trends include: industrial sector ($\tau=-0.39$, $p=0.008$); residential sector ($\tau=-0.75$, $p<0.0001$); and the transportation sector ($\tau=-0.40$, $p=0.006$).

Figure 1. CO_2 Emissions from Fossil Fuel Combustion, LA, 1990-2013

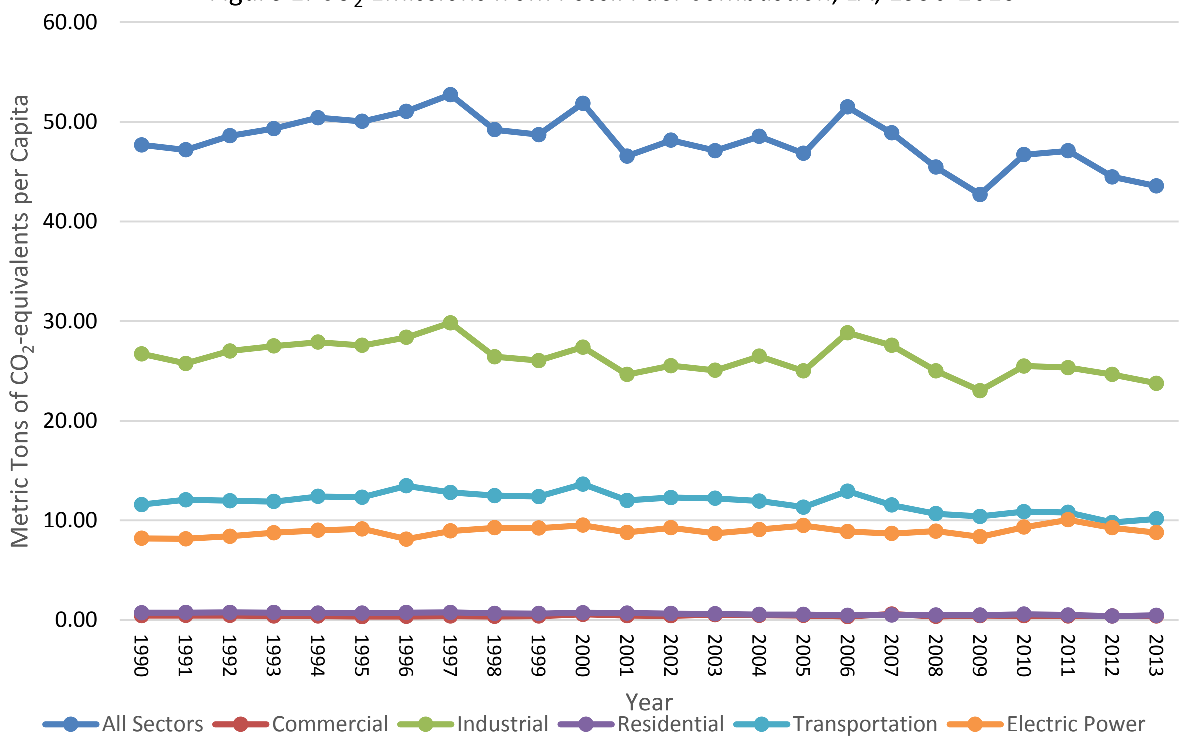
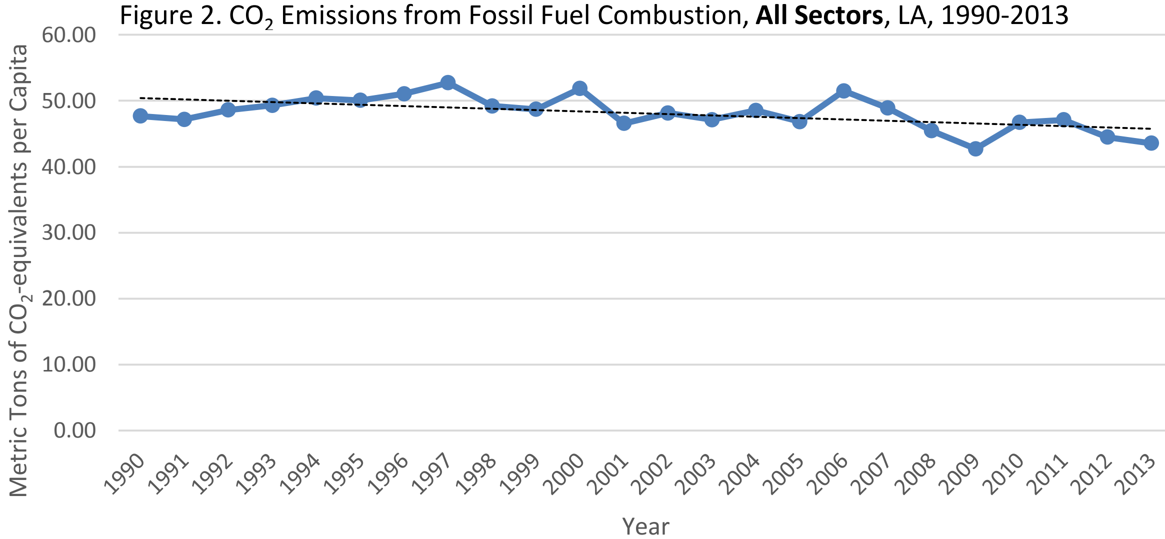


Figure 2. CO_2 Emissions from Fossil Fuel Combustion, **All Sectors**, LA, 1990-2013



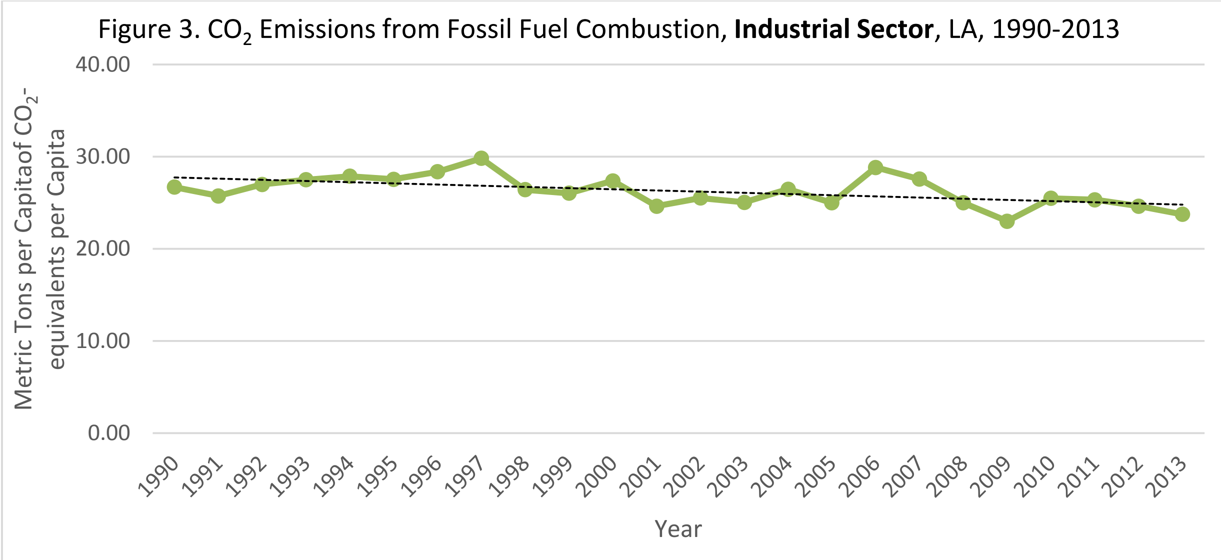


Figure 3. CO_2 Emissions from Fossil Fuel Combustion, **Industrial Sector**, LA, 1990-2013
Metric Tons per Capitaof CO_2-equivalents per Capita
40.00
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20.00
10.00
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

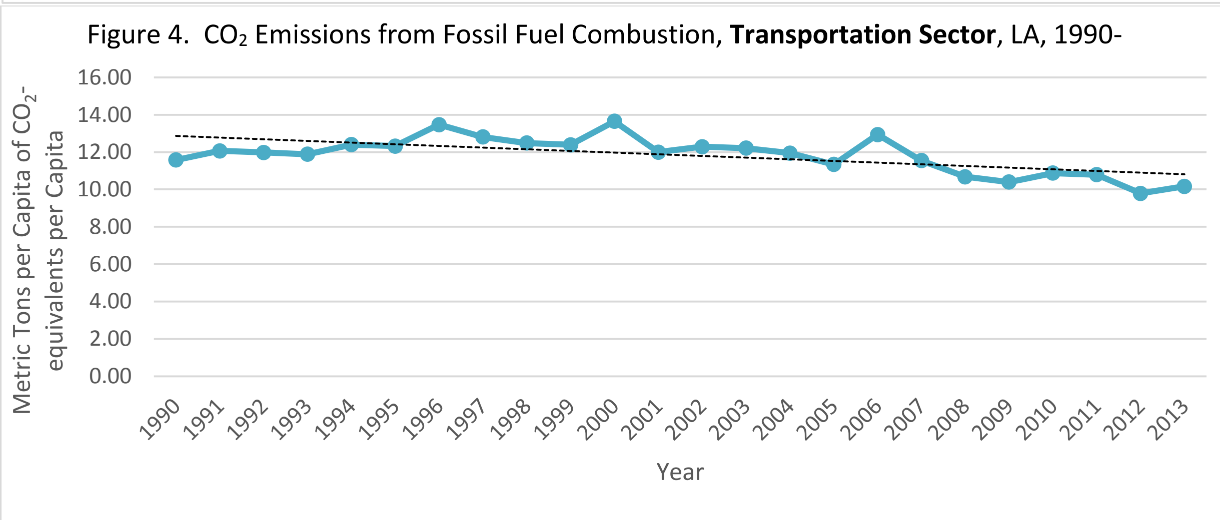
Figure 4. CO_2 Emissions from Fossil Fuel Combustion, **Transportation Sector**, LA, 1990-
Metric Tons per Capita of CO_2-equivalents per Capita
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
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1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

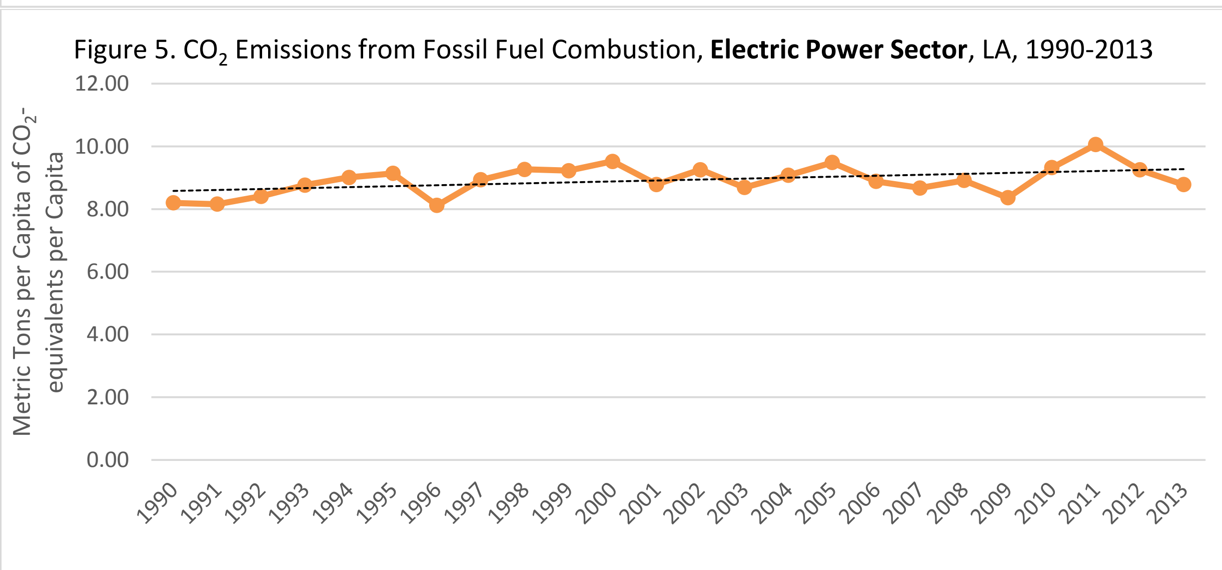
Figure 5. CO_2 Emissions from Fossil Fuel Combustion, **Electric Power Sector**, LA, 1990-2013
Metric Tons per Capita of CO_2-equivalents per Capita
12.00
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8.00
6.00
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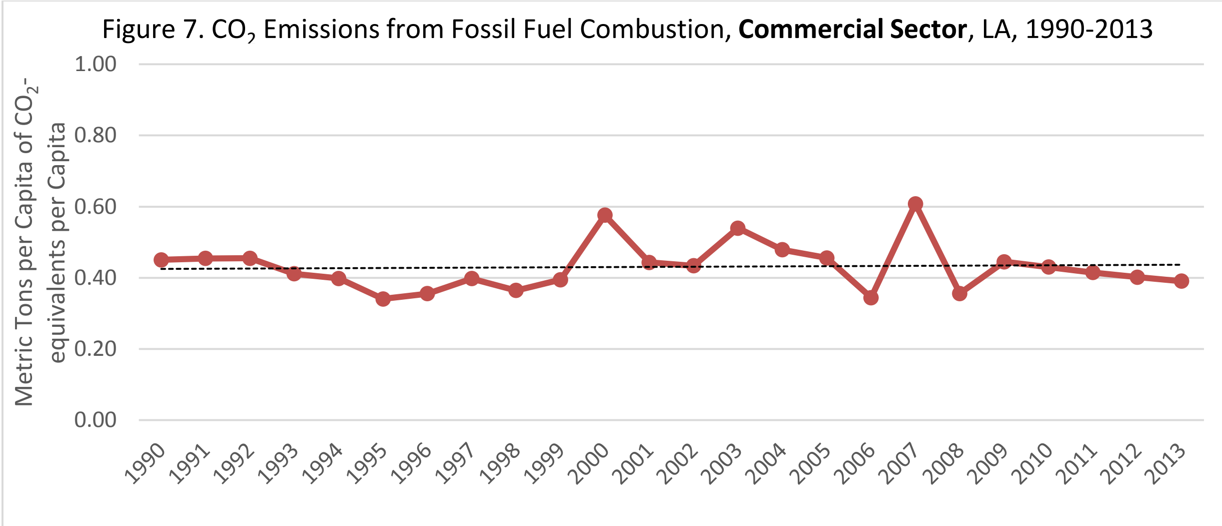
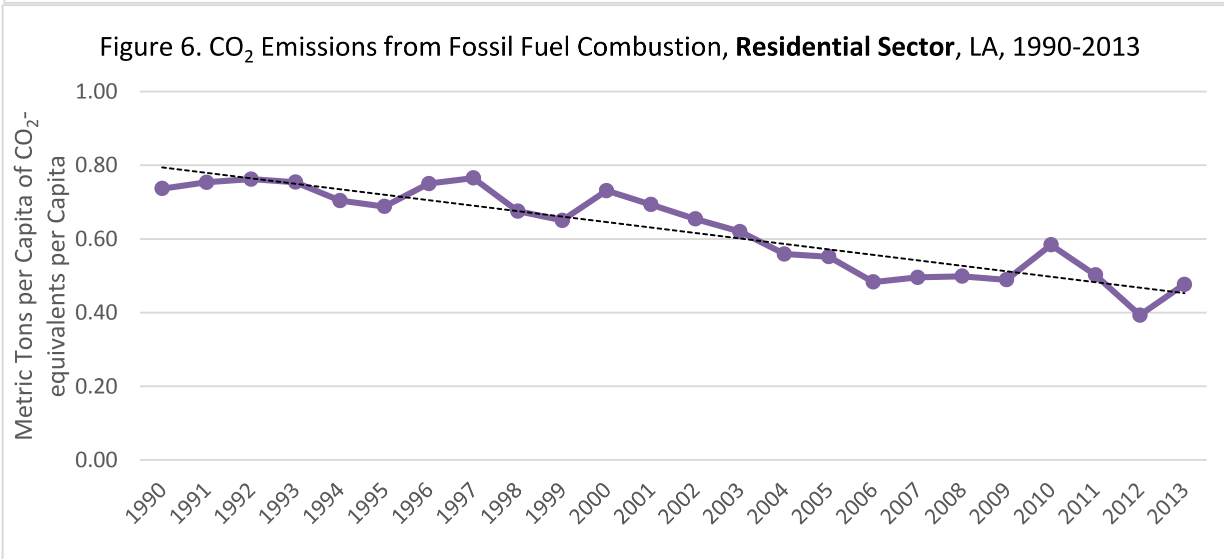
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013





Air mass stagnation events

Several factors dictate the degree of gaseous and particulate pollution in an area, one of which is temporal build up due to air mass stagnation. Stagnation "consist of light winds so that horizontal dispersion is at a minimum, a stable lower atmosphere that effectively prevents vertical escape, and no precipitation to wash any pollution away" (National Oceanic and Atmosphere Administration). Air mass stagnation events are not directly related to pollutant emissions, but they can worsen the effects of existing air pollution (Council of State and Territorial Epidemiologists, 2009). Stagnation events result in increased ozone production as pollutants are heated by the sun, and are an important indicator of air quality changes associated with climate variability (National Oceanic and Atmosphere Administration; U.S. Climate Change Science Program, 2008). Stagnation events can be expected to increase in frequency as weather conditions favorable to heat waves increase (U.S. Climate Change Science Program, 2008).

Table 1 displays the average number of air mass stagnation events per year and for the winter and summer seasons, as well as the average monthly maximum number of events in Louisiana for 1973-2008. The yearly average was 184.25 (SD: 15.50). In comparing summer to winter, the average number of air mass stagnation events was significantly higher in the summer months of June, July, and August at an average of 27.30 (SD:

1.75) per month, compared to the winter monthly average of 6.12 (SD: 2.02) for November, December, January, and February ($t=42.17$, $p<0.0001$).

Table 1. Average Air Mass Stagnation Events, LA, 1973-2008

	Mean	Standard Deviation	95% Confidence Interval
Yearly Total	184.25	15.50	(179.11, 189.39)
Summer (Jun.-Aug.) Average	27.30	1.75	(26.73, 27.87)
Winter (Nov.-Feb.) Average	6.12	2.02	(5.46, 6.78)
Monthly Maximum Average	29.72	1.32	(29.29, 30.15)

Figure 8 displays total annual number of air mass stagnation events in Louisiana 1973 to 2008. The number of events ranged from a high of 214 (1990) to a low of 125 events (2008). Figure 9 displays the average number of air mass stagnation events by month. May through October experienced on average more than 15 air mass stagnation events per month (range: 18.67-29.00) while other months had, on average, 10 or fewer events. Figure 10 displays the overall average number of air mass stagnation events for the reported time period, as well as the average number of events occurring in the summer and winter seasons. There was a significant downward trend in the average number of air mass stagnation events in the summer months ($\tau=-0.30$, $p=0.01$). There was an upward trend in the average number of events per year and in the number of winter events. These trends were not significant. There was no significant difference between the yearly average number of air mass stagnation events in summer or winter for 1973-2008 ($F=0.19$, $p=1.00$), which varied from 10.42 to 17.83 average events per year.

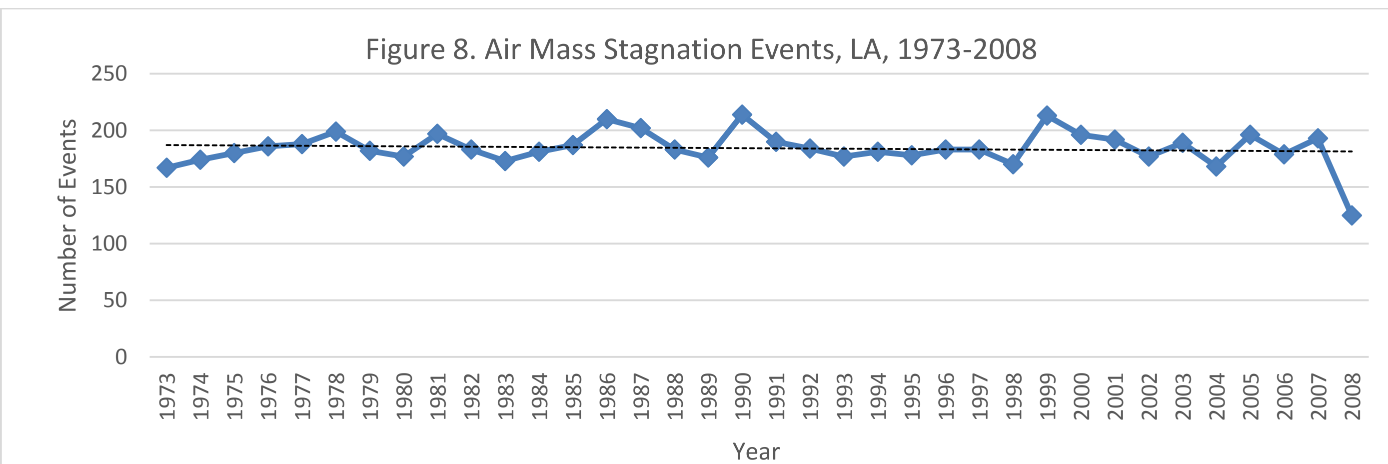


Figure 8. Air Mass Stagnation Events, LA, 1973-2008

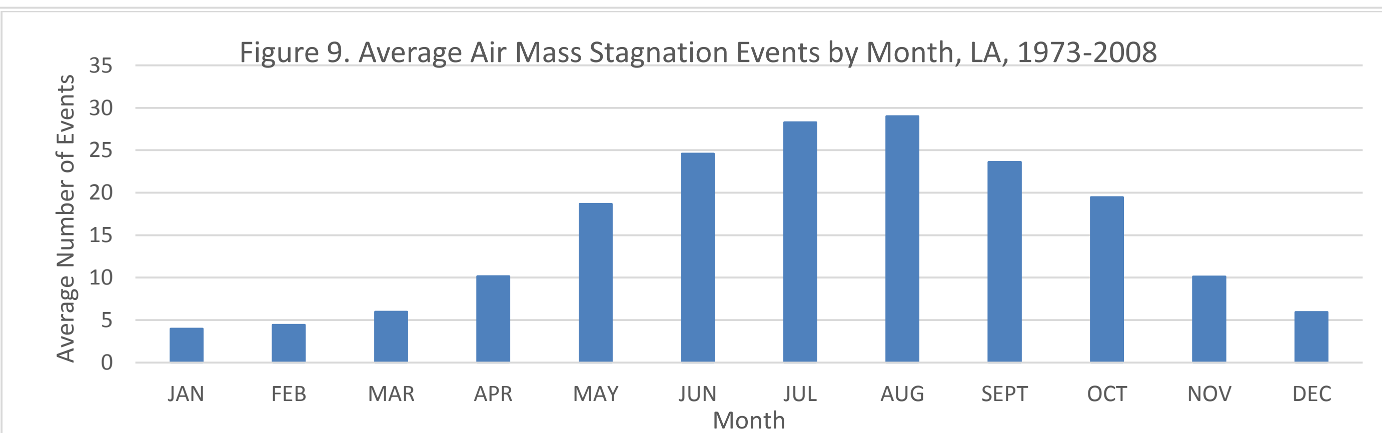


Figure 9. Average Air Mass Stagnation Events by Month, LA, 1973-2008

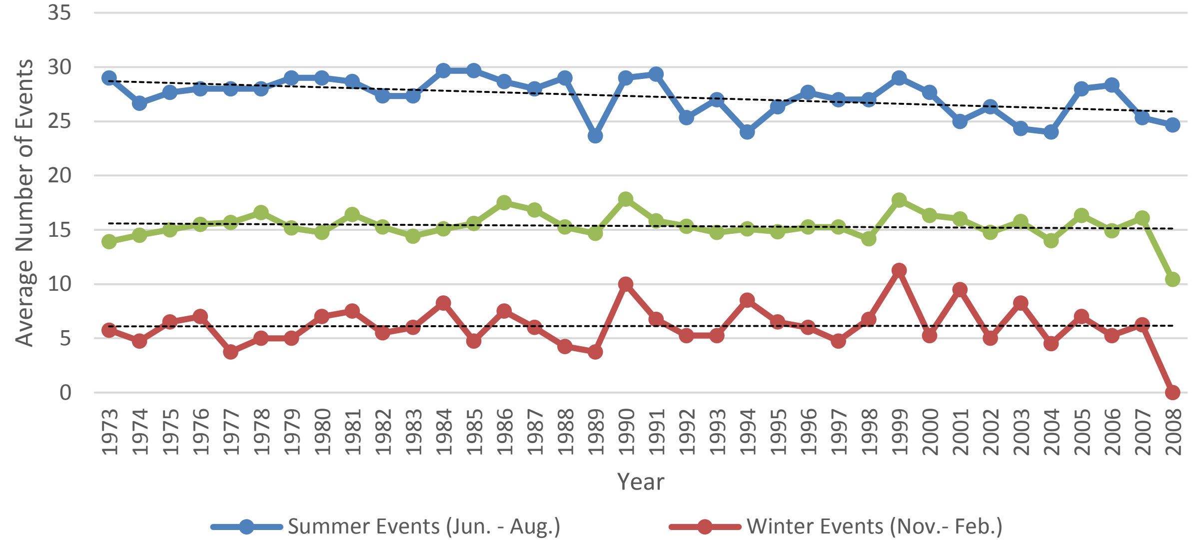


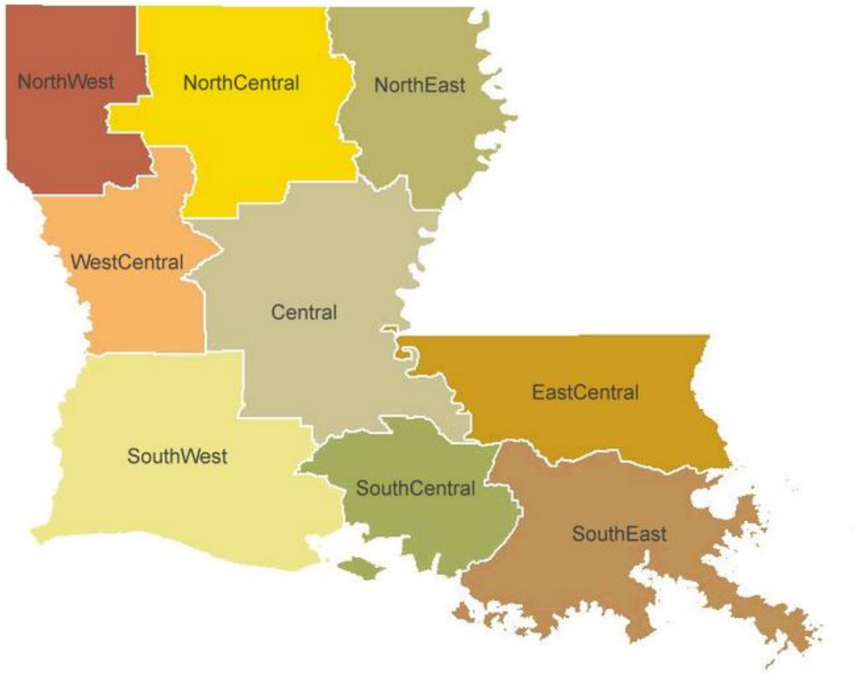
Figure 10. Average Air Mass Stagnation Events by Season, LA, 1973-2008

Maximum, minimum, and diurnal temperature

In the past century overall global surface temperature has increased by 0.7-1.4 ^{o} F (National Research Council, 2000). Climate change is predicted to increase the number of extremely hot days, and decrease the number of extremely cold days (McGeehin & Mirabelli, 2001). Heat extremes increase morbidity and mortality as well as influence economic, agricultural, manufacturing, energy, and infrastructure costs (Council of State and Territorial Epidemiologists, 2013c). On average there are 400 deaths in the U.S. directly related to excessive heat; however, this number is likely an underestimate because of inconsistent capture of the primary cause of heat-related deaths on death certificates (Basu & Samet, 2002; Donoghue, et al., 1997; Shen, Howe, Alo , & Moolenaar, 1998). Infants, children under 1 year of age, and the elderly are populations at higher risk of mortality due to elevated ambient temperatures (Basu & Samet, 2002; Centers for Disease Control and Prevention, 2002; Foroni, et al., 2007). As the U.S. becomes more urbanized and the elderly population continues to increase, heat-related morbidity and mortality will become an increasingly important public health issue (Hobbs & Damon, 1996). Extreme heat is also an important occupational health issue for outdoor workers (Harduar Morano, et al., 2015).

Daily maximum and minimum temperatures and diurnal temperature range (DTR) data are collected by the National Oceanic and Atmospheric Administration (NOAA) via weather monitoring stations located in Louisiana's nine climate regions. Parishes within each climate division share nearly homogenous characteristics regarding temperature, rainfall, and humidity (Guttman & Quayle, 1996). Diurnal temperature range is the difference between the daily maximum and minimum temperature. Maximum and minimum temperature and DTR are more sensitive to temperature variations than average temperature as averages do not provide information about changes in maximum or minimum temperatures (Council of State and Territorial Epidemiologists, 2013c). Data for the summer season (Jun 21st – Sep 22nd) from each climate region were analyzed for the years 1990-2014. The annual number of days the temperature reached 95^{o}F or higher in the state is presented, as well as the average annual number of days the temperature reached 95^{o}F or higher, the average maximum, average minimum, and average DTR for each climate region (see Figure 11 for a map of Louisiana's nine climate regions).

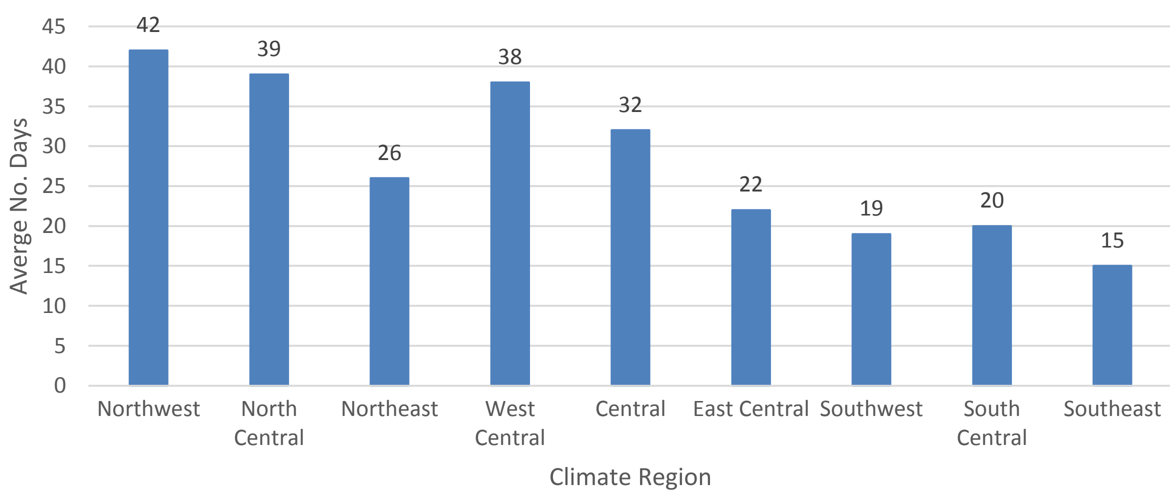
Figure 11. Louisiana Climate Regions



Average Number of Days ≥ 95⁰F by Climate Region

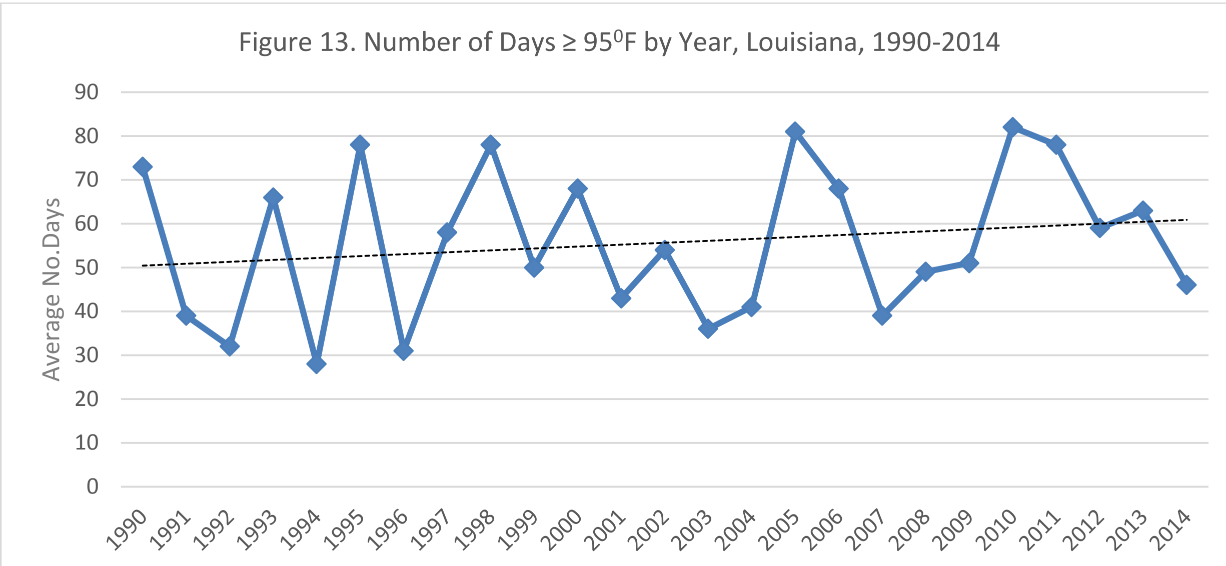
The Northwest, NorthCentral, WestCentral, and Central climate regions all had an average of 30 days or more per year where temperatures hit 95⁰F or higher (Figure 13). The Northwest was the hottest with 42 days. The three southern climate regions had 20 or fewer days of ≥ 95⁰F temperatures. The Southeast had the fewest days of temperatures ≥ 95⁰F with 15.

Figure 12. Average Number of Days ≥ 95⁰F by Climate Region, LA, 1990-2014



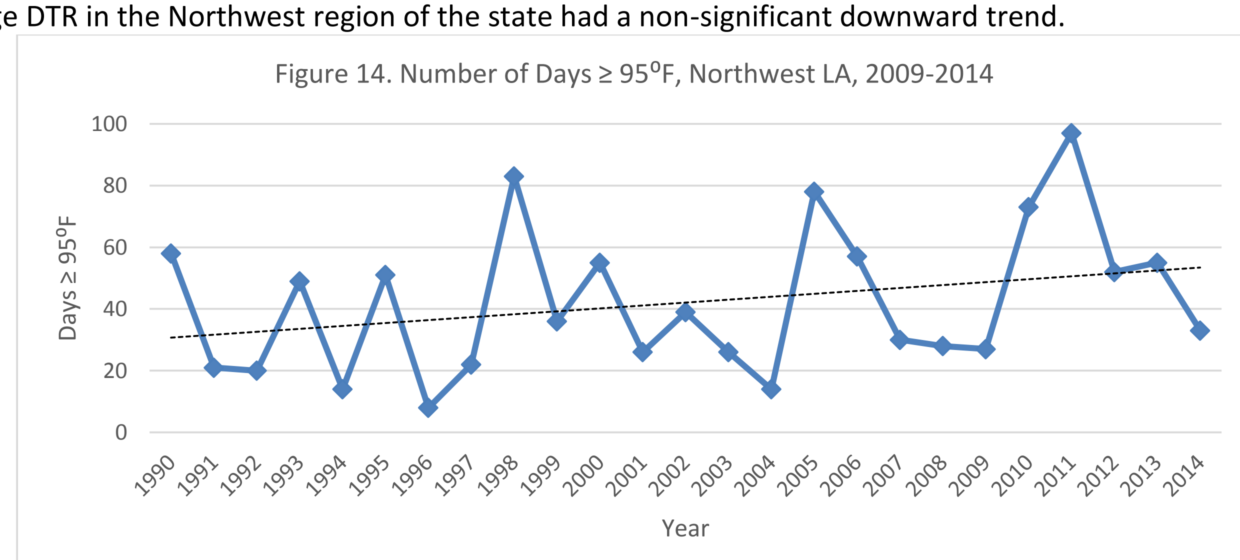
Annual Number of Days ≥ 95⁰F in Louisiana

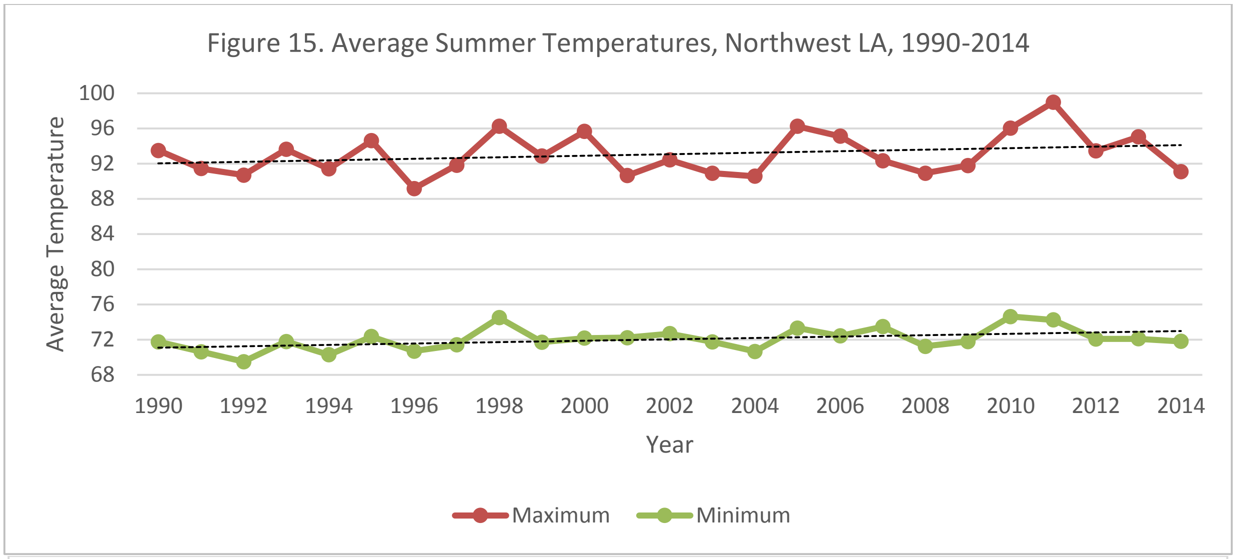
The average number of days with a temperature ≥ 95⁰F in the state was 56 (SD=17.15). The year with the fewest number of days ≥ 95⁰F was 1994 with 28; the year with the most was 2011 with 82. The Mann-Kendall test for trend was performed. The number of days with a temperature ≥ 95⁰F trended upward over time, but the trend was not significant.

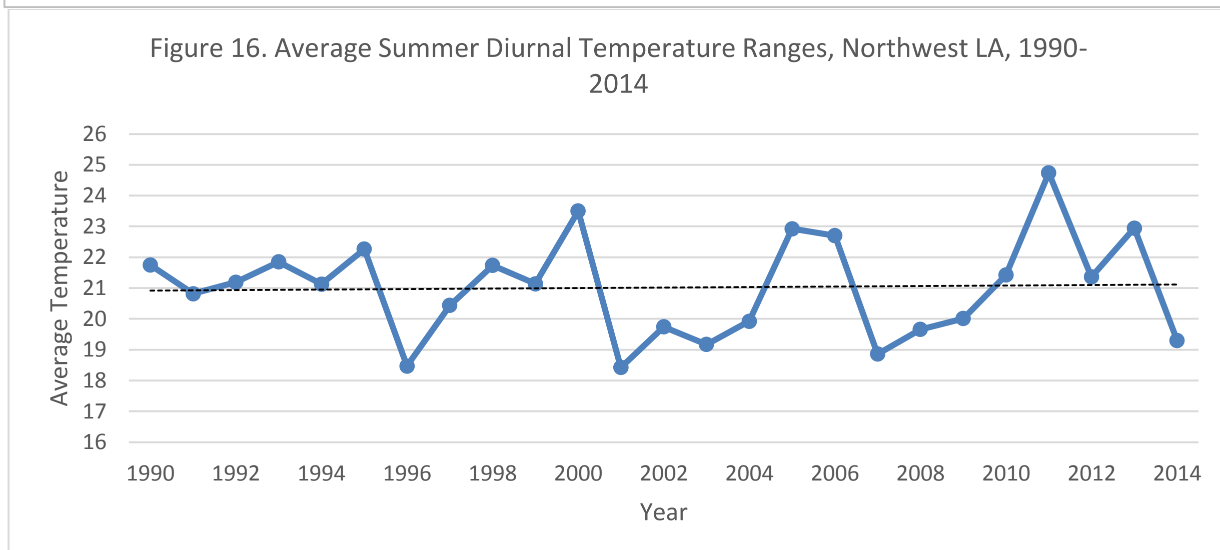


Northwest Louisiana

In the Northwest region of the state, 2011 had the most number of days where the temperature was ≥ 95⁰ F with 97; 1996 had the least with 8 days (see Figure 14). There was a non-significant increasing trend in the number of days ≥ 95⁰ F. Figure 15 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature of 99⁰F occurred in 2011; the lowest, 89⁰F, occurred in 1996. The highest average minimum temperature of 74⁰F occurred in 1998; the lowest, 69⁰F, occurred in 1992. Figure 16 displays the average DTR for the summer season. There was a significant upward trend in average minimum summer temperature ($\tau=0.33$, $p=0.03$). Average maximum temperature and average DTR in the Northwest region of the state had a non-significant downward trend.







NorthCentral Louisiana

In the NorthCentral region, 2010 and 2011 were nearly tied for the most number of days where the temperature was ≥ 95^{o} F with 90 and 89, respectively; 2004 had the least with 4 days (Figure 17). There was a slightly increasing trend in the number of days ≥ 95^{o} F that was non-significant. Figure 18 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature of 97^{o}F occurred in 2010 and 2011; the lowest, 89^{o}F, occurred in 2004. The highest average minimum temperature of 75^{o}F occurred in 2010; the lowest, 68^{o}F, occurred in 2004. Figure 19 displays the average DTR for the summer season. There was an increasing trend in average maximum temperature and average DTR, and a decreasing trend in the average minimum temperature; however, none of these trends were significant.

Figure 17. Number of Days ≥ 95°F, North Central LA, 1990-2014

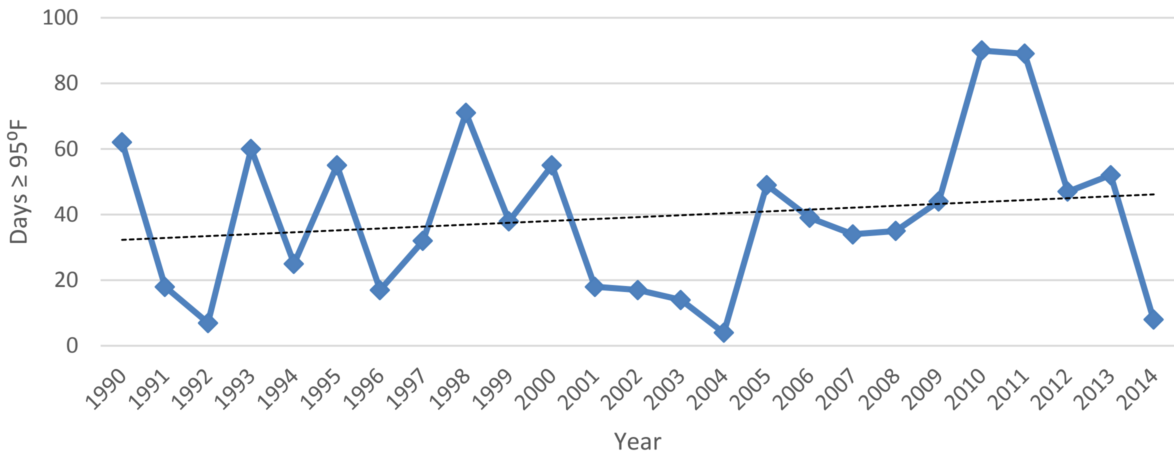


Figure 18. Average Summer Temperatures, North Central LA, 1990-2014

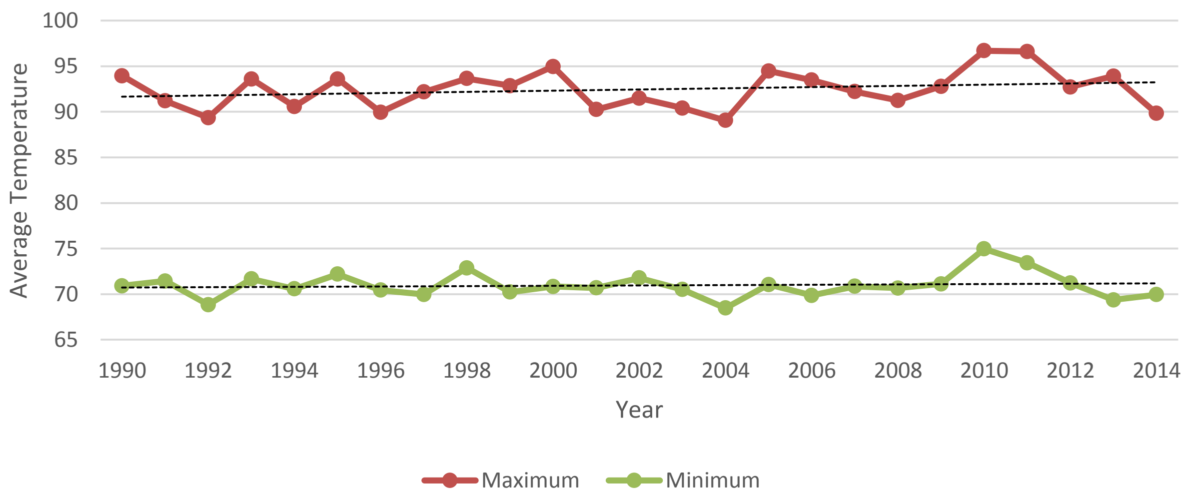
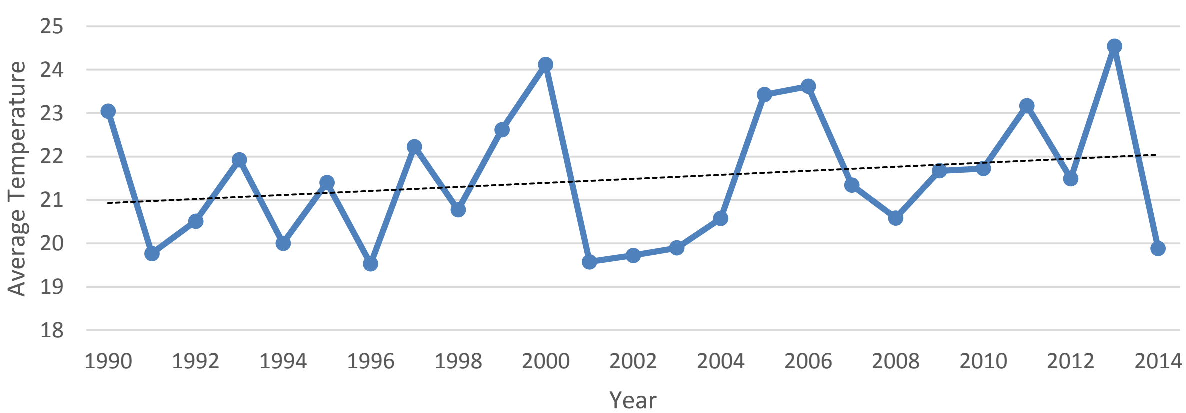


Figure 19. Average Summer Diurnal Temperature Ranges, North Central LA, 1990-2014



Northeast Louisiana

In the Northeast, 1998 had the most number of days where the temperature was ≥ 95° F with 62; 1992 had the least with 1 day (see Figure 20). There was an increasing trend in the number of days ≥ 95° F that was non-significant. Figure 21 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature of 95^{o}F occurred in 2000; the lowest, 87^{o}F, occurred in 1992. The highest average minimum temperature of 74^{o}F occurred in 1998 and 2010; the lowest, 70^{o}F, occurred in 1992, 1994, 2004, and 2014. Figure 22 displays the average DTR for the summer season. There was a decreasing trend in average maximum and minimum temperature, and an increasing trend in the average DTR; however, none of these trends were significant.

Figure 20. Number of Days ≥ 95^{o}F, Northeast LA, 1990-2014

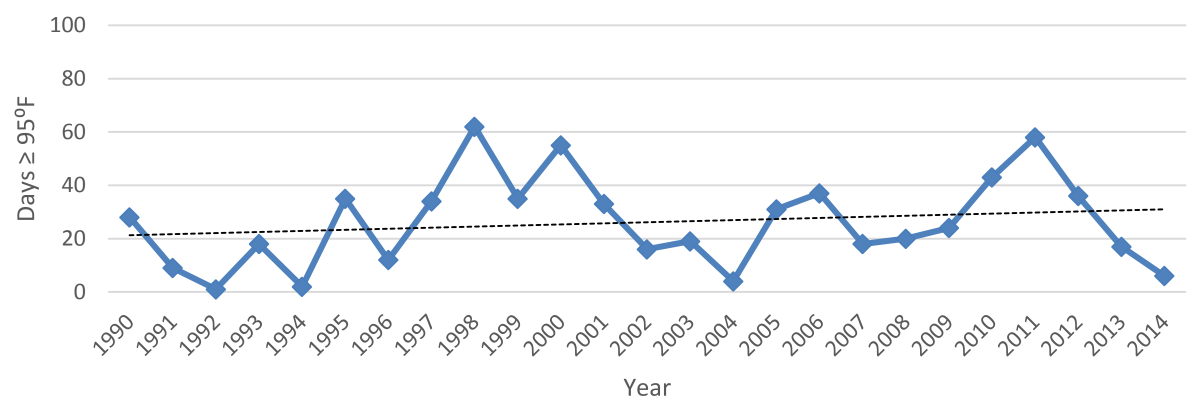
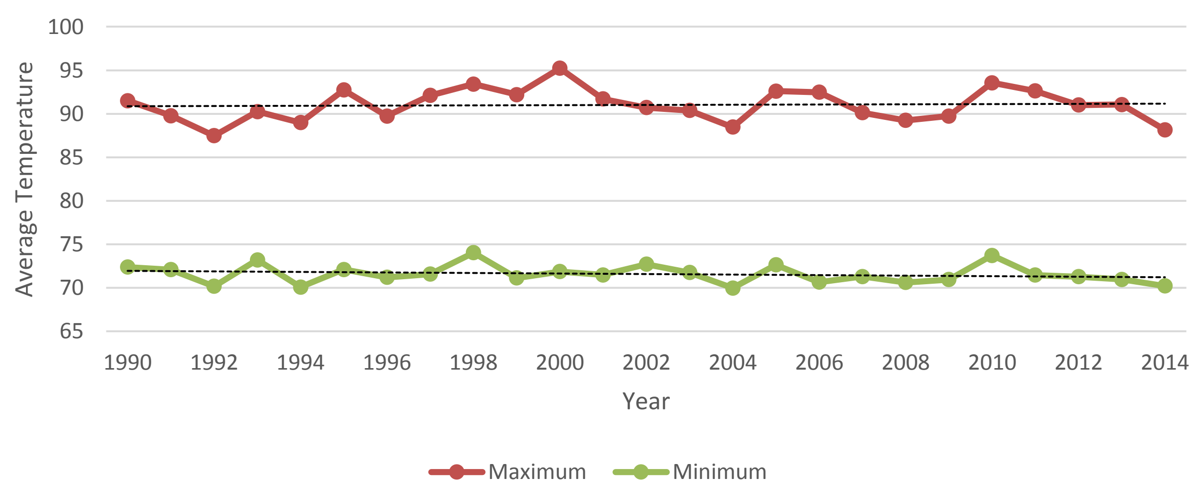
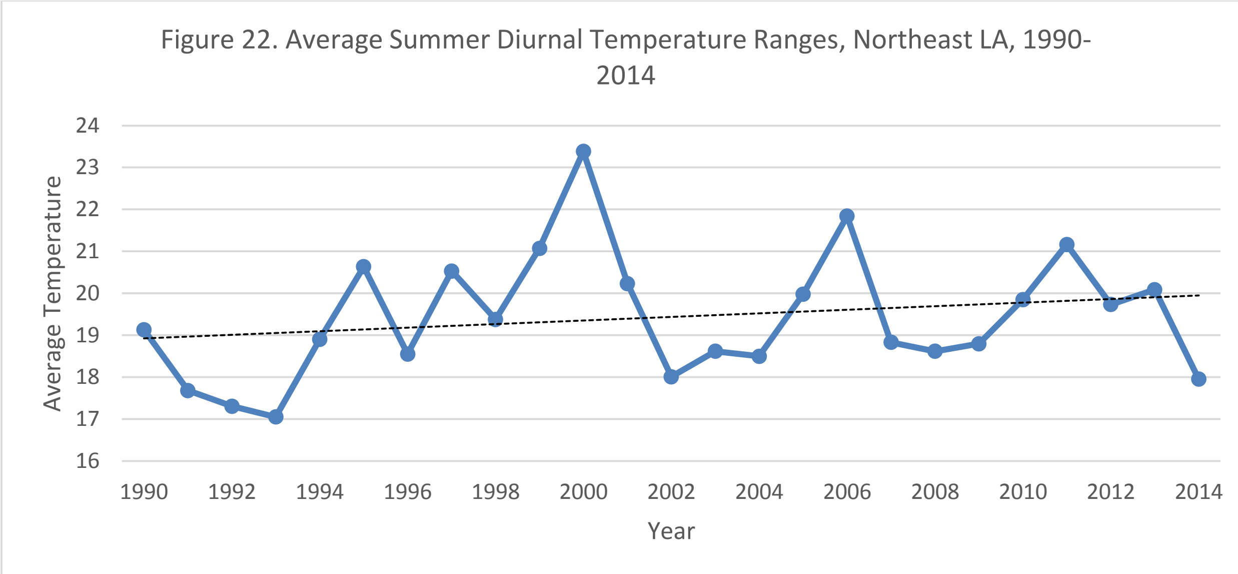


Figure 21. Average Summer Temperatures, Northeast LA, 1990-2014





West Central Louisiana

In West Central LA, 2011 had the most number of days where the temperature was ≥ 95° F with 89; 1991 had the least with 1 day (see Figure 23). There was an increasing trend in the number of days ≥ 95° F that was non-significant. Figure 24 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 96°F in 2000; the lowest average maximum temperature was 89°F in 1991. The average minimum temperature was highest in 2010 when it was 72°F; the lowest was in 67°F in 2004. Figure 25 displays the region's average DTR for the summer season. There was an increasing trend in average maximum and minimum temperature, and a decreasing trend in the average DTR; however, none of these trends were significant.

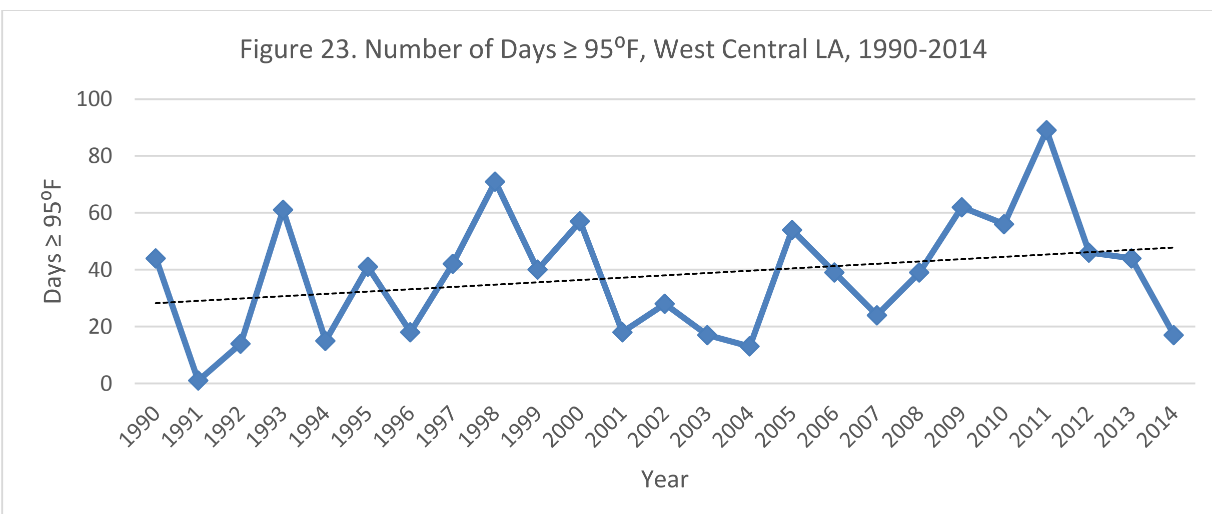


Figure 24. Average Summer Temperatures, West Central LA. 1990-2014

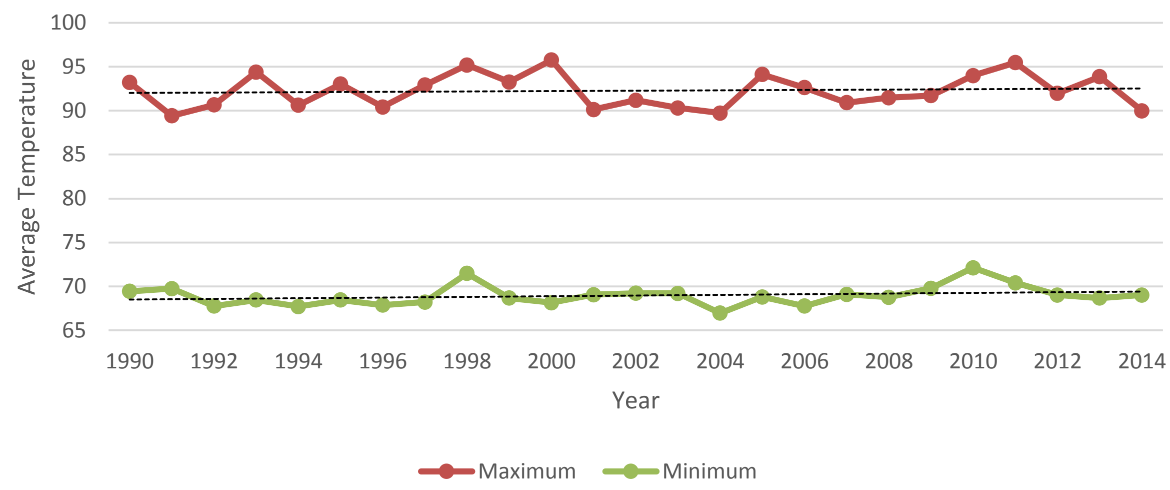
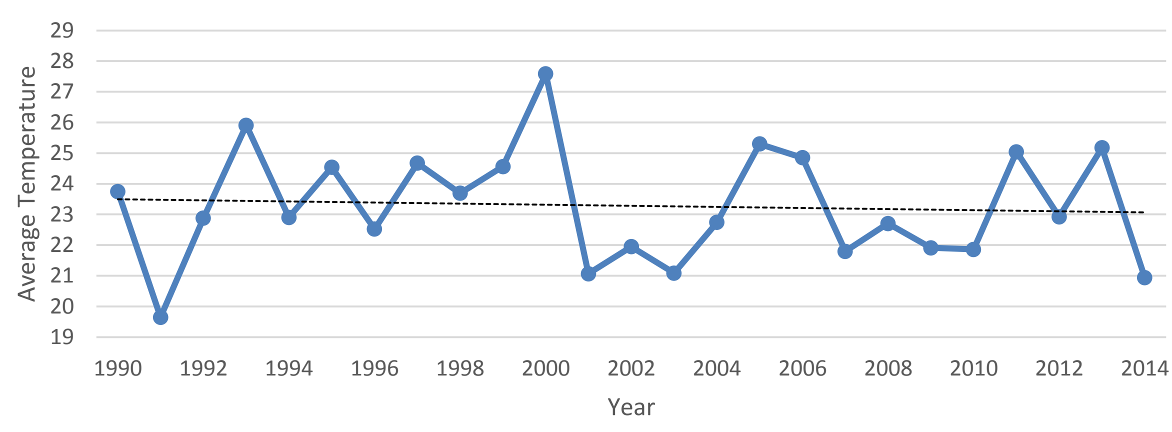
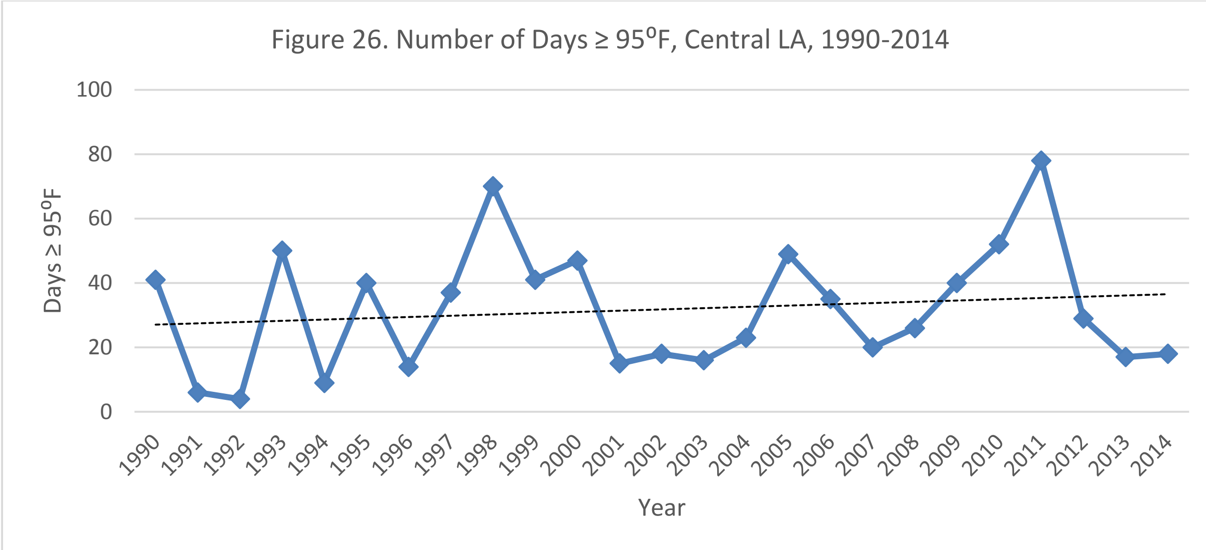


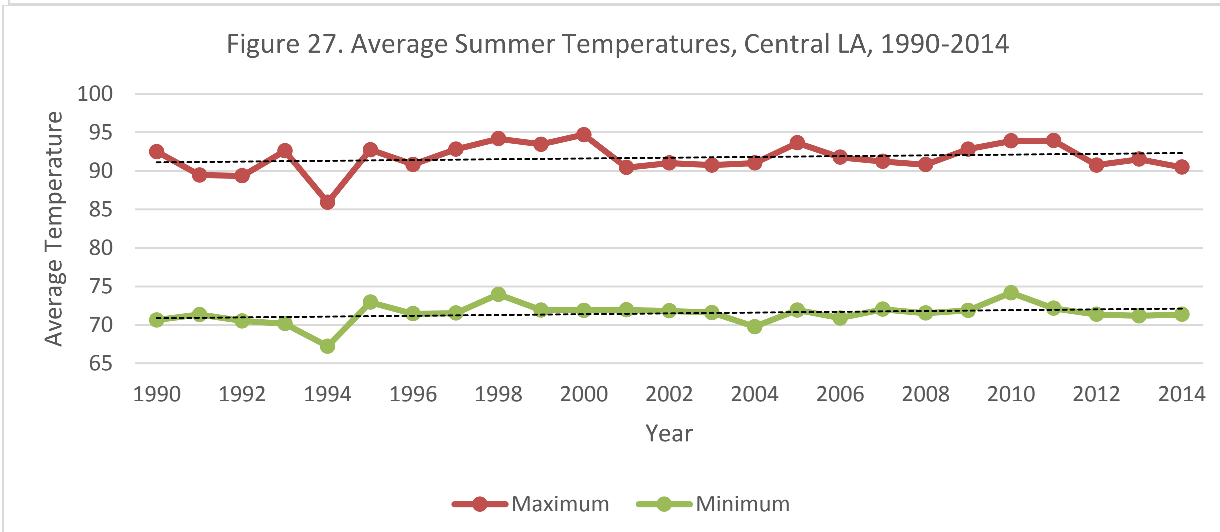
Figure 25. Average Summer Diurnal Temperature Ranges, West Central LA. 1990-2014

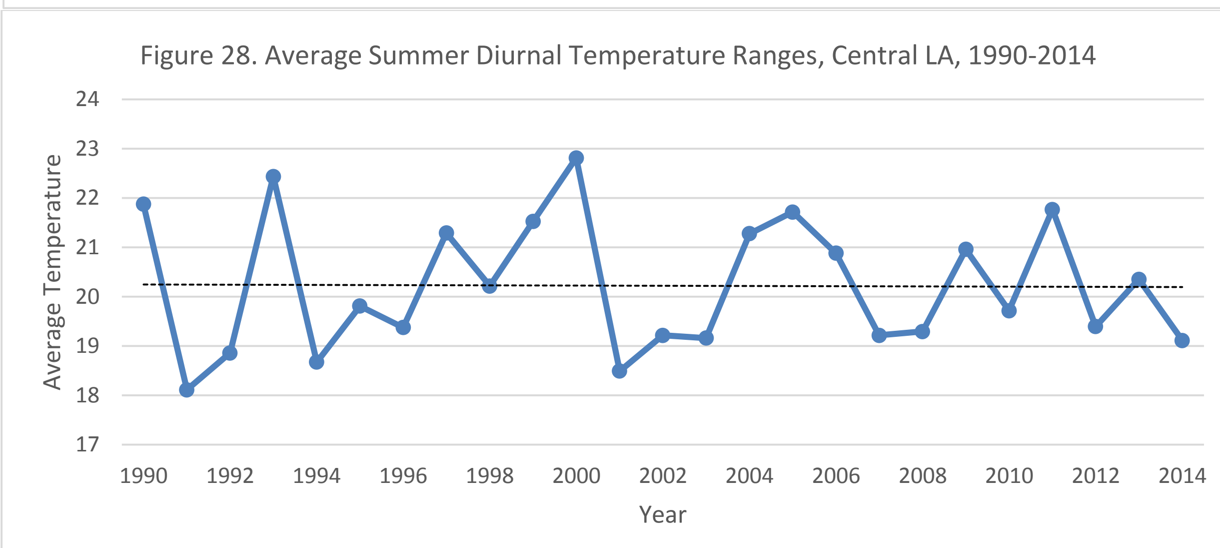


Central Louisiana

In Central LA, 2011 had the most number of days where the temperature was ≥ 95^{o} F with 78; 1992 had the least with 4 days (see Figure 26). There was an increasing trend in the number of days ≥ 95^{o} F that was non-significant. Figure 27 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 95^{o}F in 2000; the lowest average maximum temperature was 86^{o}F in 1994. The average minimum temperature was highest in 1998 and 2010 when it was 74^{o}F; the lowest was in 67^{o}F in 1994. Figure 28 displays the region's average DTR for the summer season. There was an increasing trend in average maximum and minimum temperature as well as average DTR; however, none of these trends were significant.







East Central Louisiana

In East Central LA, 2011 had the most number of days where the temperature was ≥ 95º F with 64; 1994 and 2001 had no days where the temperature was ≥ 95º F (see Figure 29). There was an increasing trend in the number of days ≥ 95^{o} F that was non-significant. Figure 30 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 94^{o}F in 2005; the lowest average maximum temperature was 89^{o}F in 1994 and 2001. The average minimum temperature was highest in 2010 when it was 75^{o}F; the lowest was in 71^{o}F in 1996, 1997, and 2004. Figure 31 displays the region's average DTR for the summer season. There was an increasing trend in the average maximum and minimum temperature and decreasing trend in the DTR. Only the increasing trend in average minimum summer temperature was significant (τ=0.34, p=0.03).

Figure 29. Number of Days ≥ 95^{o}F, East Central LA, 1990-2014

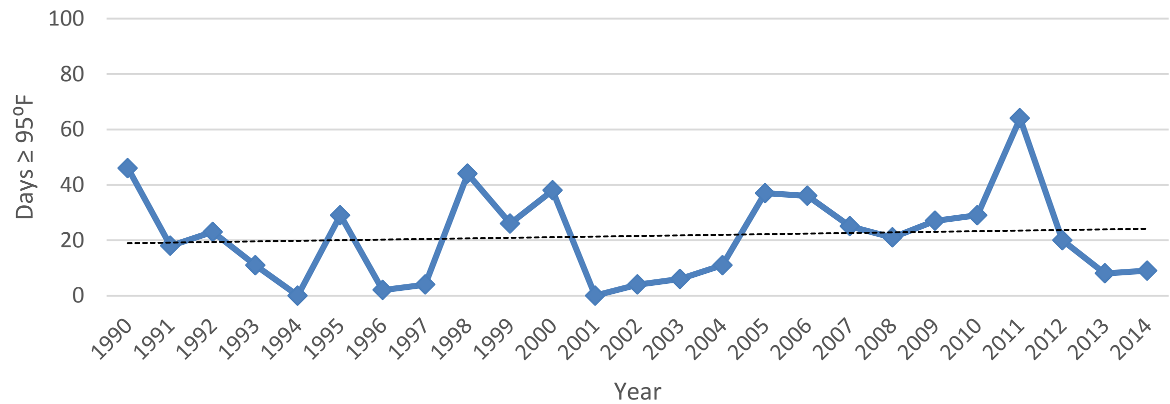
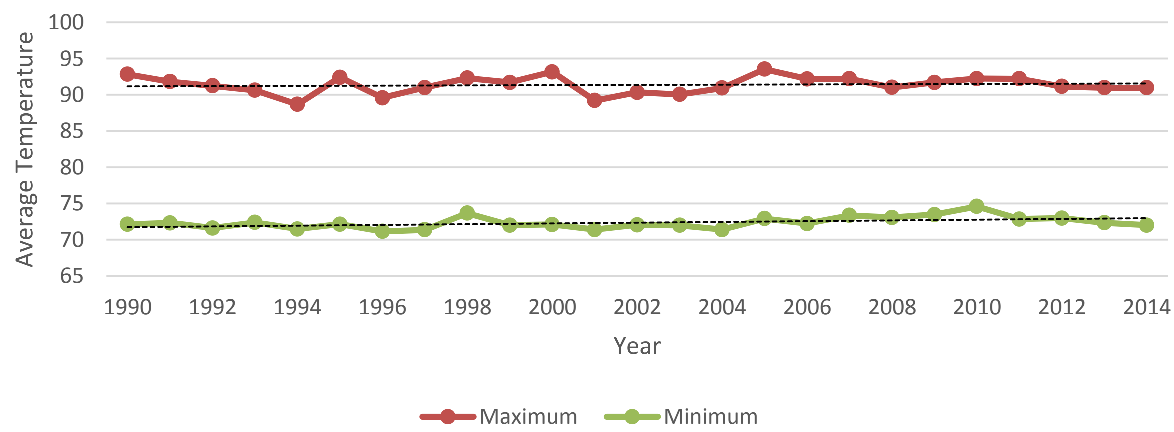
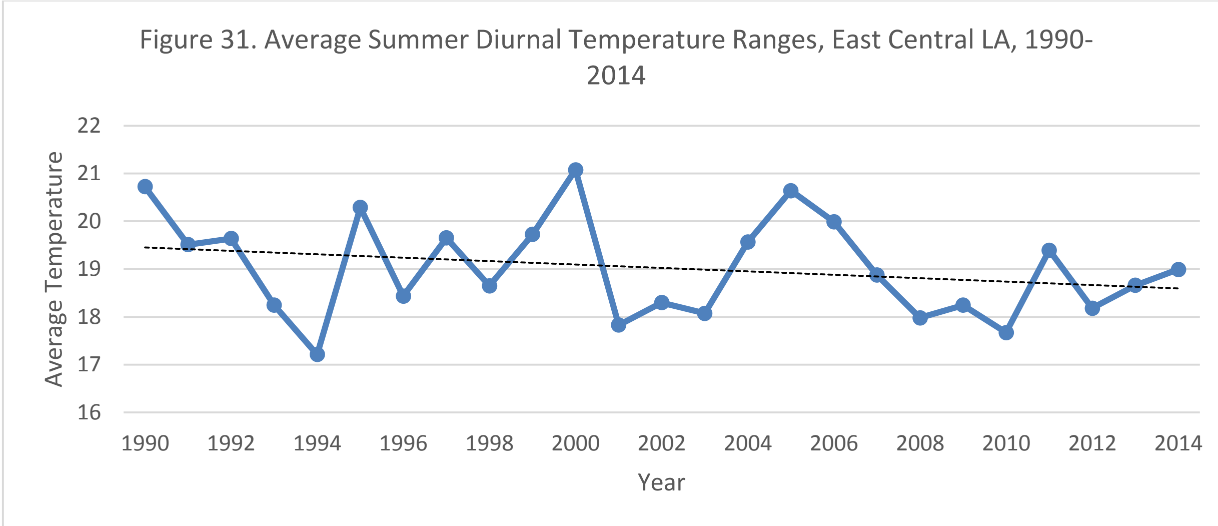


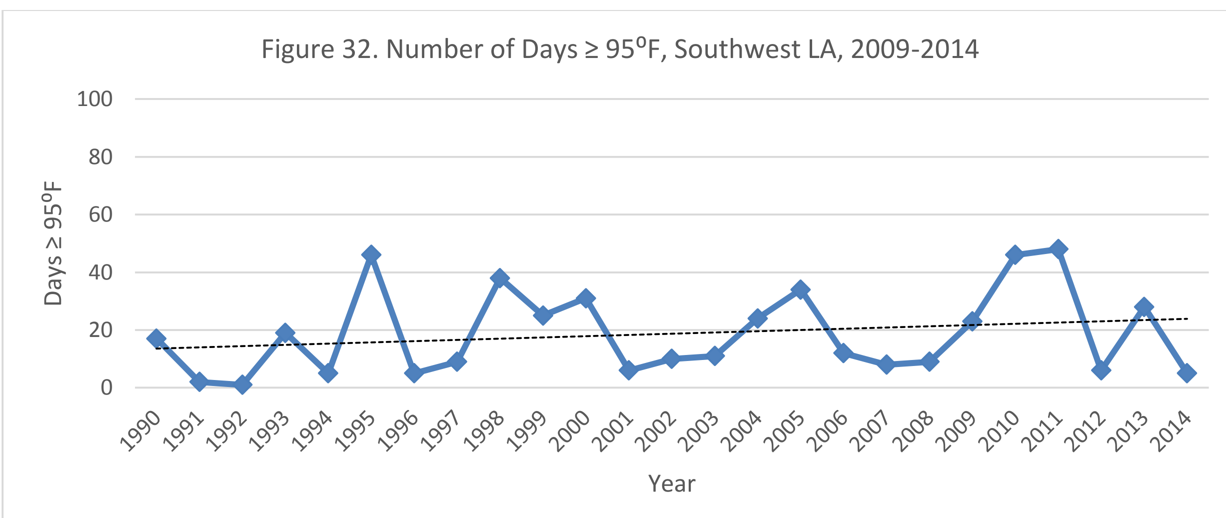
Figure 30. Average Summer Temperatures, East Central LA, 1990-2014

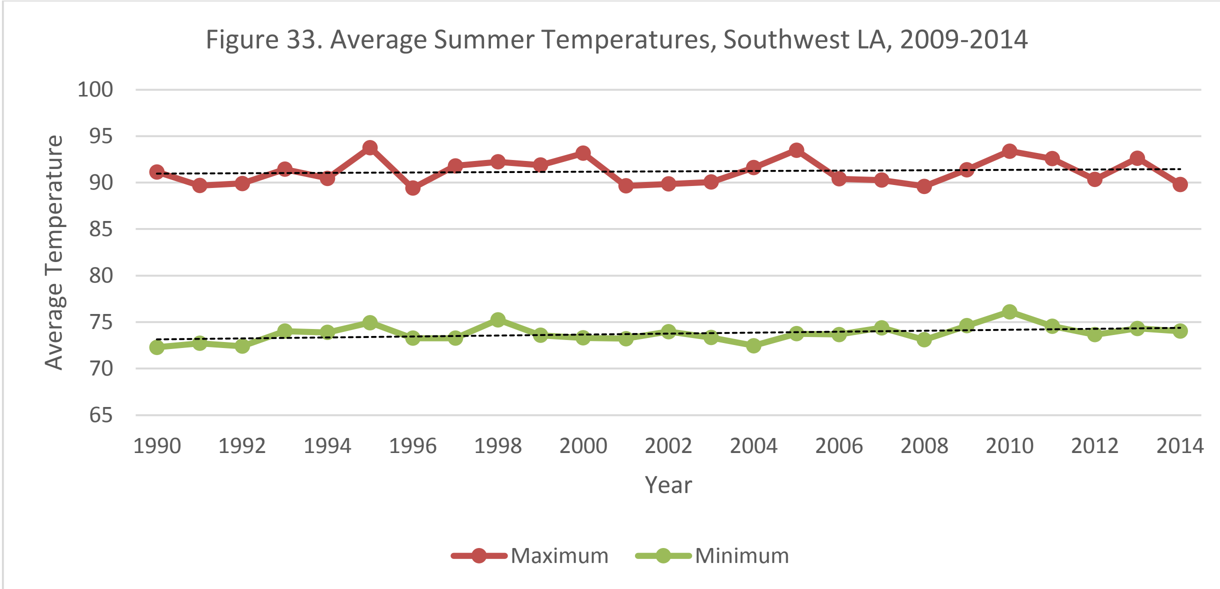


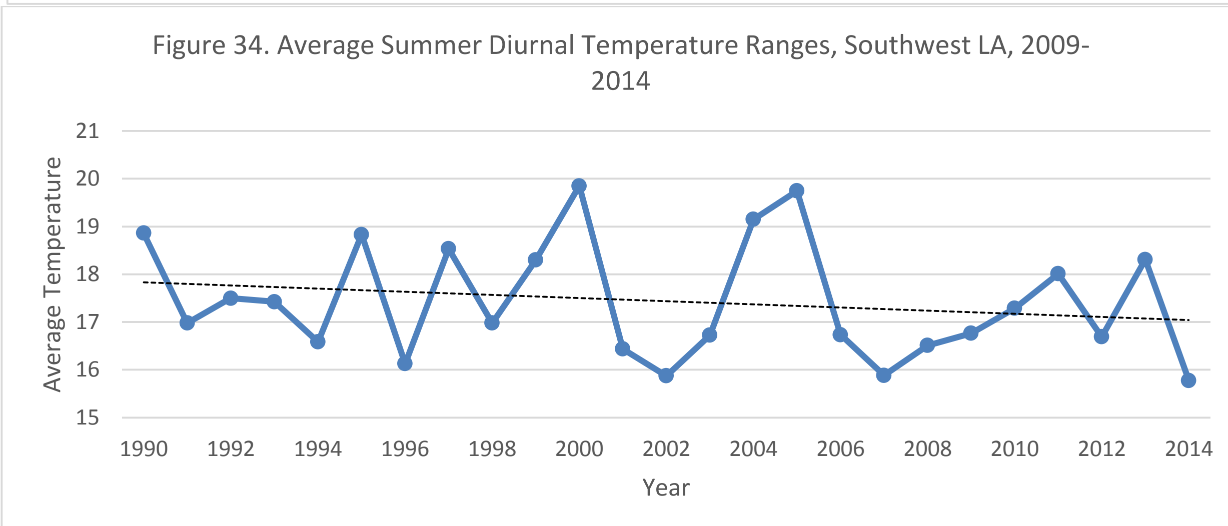


Southwest Louisiana

In Southwest LA, 2011 had the most number of days where the temperature was ≥ 95⁰ F with 48; 1992 had 1 day where the temperature was ≥ 95⁰ F (see Figure 32). There was a non-significant upward trend in the number of days ≥ 95⁰ F over time. Figure 33 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 94⁰F in 1995; the lowest average maximum temperature was 89⁰F in 1996. The average minimum temperature was highest in 2010 when it was 76⁰F; the lowest was 72⁰F in 1990, 1992, and 2004. Figure 34 displays the region's average DTR for the summer season. There was a significant upward trend in the average minimum temperature over time ($\tau=0.37$, $p=0.02$). There was an upward trend in the average maximum temperature, and a downward trend in average summer DTR over time; however, neither of trend was significant.







South Central Louisiana

In South Central LA, 2011 had the most number of days where the temperature was ≥ 95^{o} F with 53; 1994 and 2001 had no day where the temperature was ≥ 95^{o} F (see Figure 35). There was a non-significant upward trend in the number of days ≥ 95^{o} F. Figure 36 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 94^{o}F in 2005; the lowest average maximum temperature was 88^{o}F in 2001. The average minimum temperature was highest in 2010 when it was 76^{o}F; the lowest was in 72^{o}F in 1990, 1992, and 1994. Figure 37 displays the region's average DTR for the summer season. There was a significant upward trend in the average minimum temperature over time (τ=0.51, p=0.002). There was a non-significant downward trend in both the average maximum temperature and the average DTR.

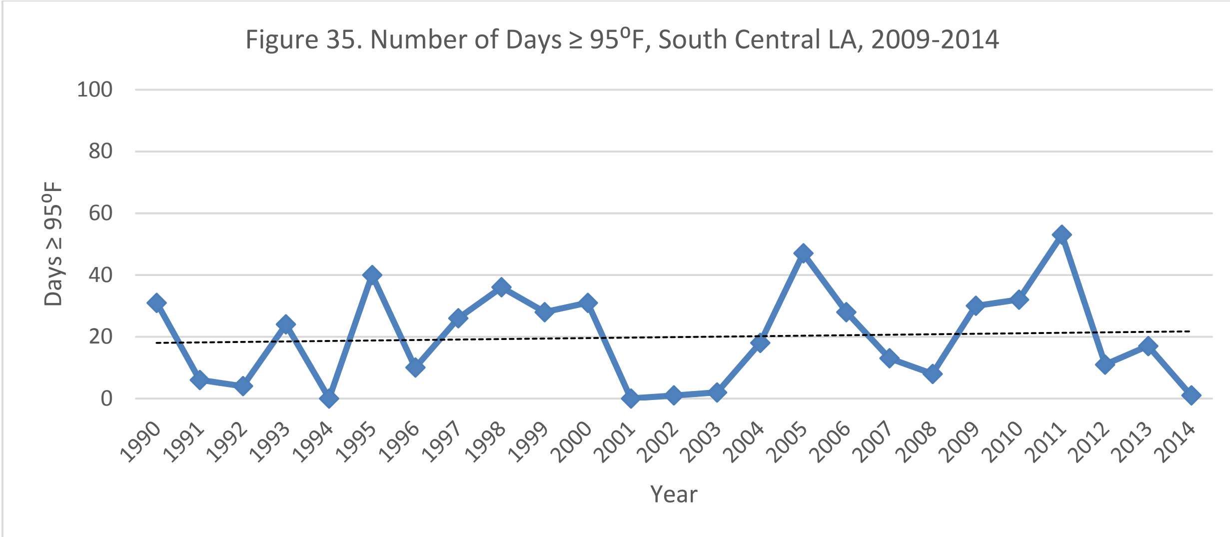


Figure 35. Number of Days ≥ 95⁰F, South Central LA, 2009-2014

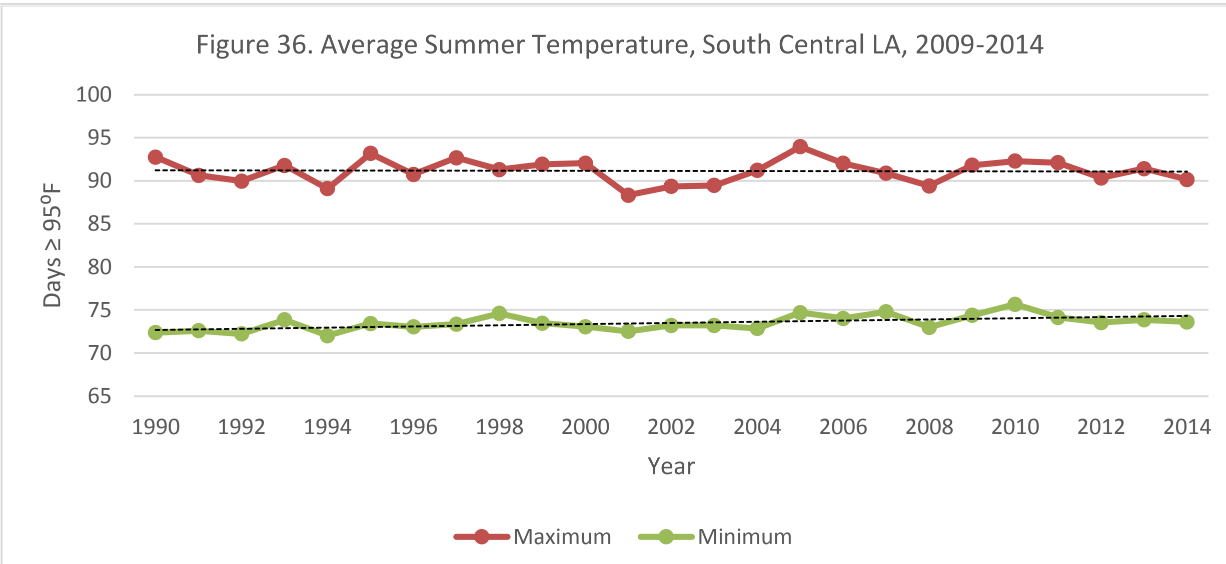


Figure 36. Average Summer Temperature, South Central LA, 2009-2014

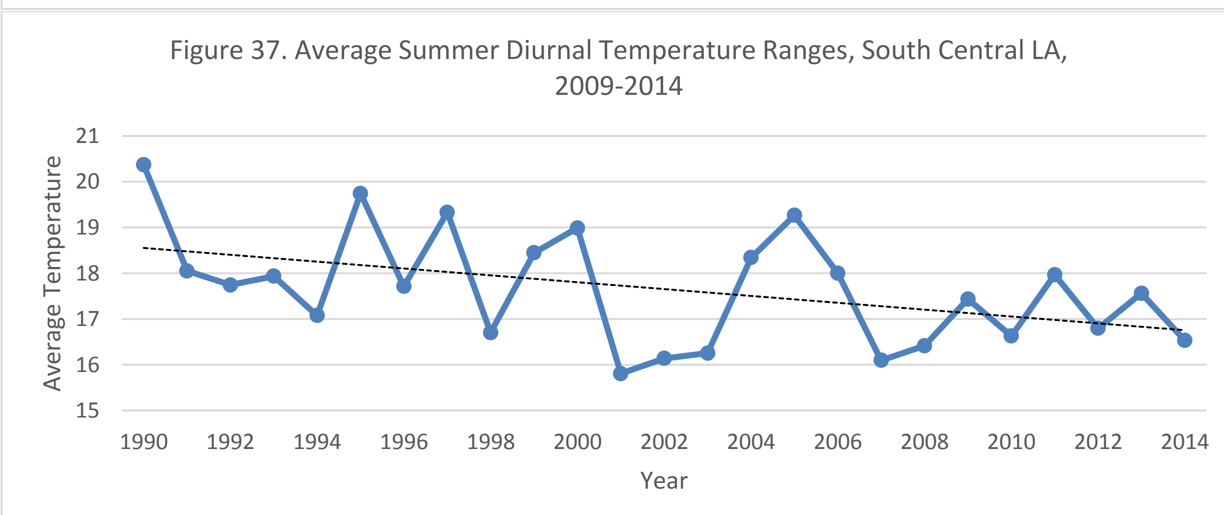


Figure 37. Average Summer Diurnal Temperature Ranges, South Central LA, 2009-2014

Southeast Louisiana

In Southeast LA, 2011 had the most number of days where the temperature was ≥ 95⁰ F with 51; 2001 had no day where the temperature was ≥ 95⁰ F (see Figure 38). There was a non-significant downward trend in the number of days ≥ 95⁰ F. Figure 39 displays the average maximum and average minimum temperatures for the years 1990-2014. The highest average maximum temperature for the time period was 93^{o}F in 1995; the lowest average maximum temperature was 89^{o}F in 1996, 2001, and 2004. The average minimum temperature was highest in 2010 when it was 77^{o}F; the lowest was in 72^{o}F in 1990, 1992, and 1994. Figure 40 displays the region's average DTR for the summer season. There was a significant upward trend in the average minimum temperature (τ=0.57, p=0.0002) and a significant downward trend in the average DTR over time (τ=-0.44, p=0.005). There was a non-significant upward trend in the average maximum temperature.

Figure 38. Number of Days ≥ 95^{o}F, Southeast LA, 2009-2014

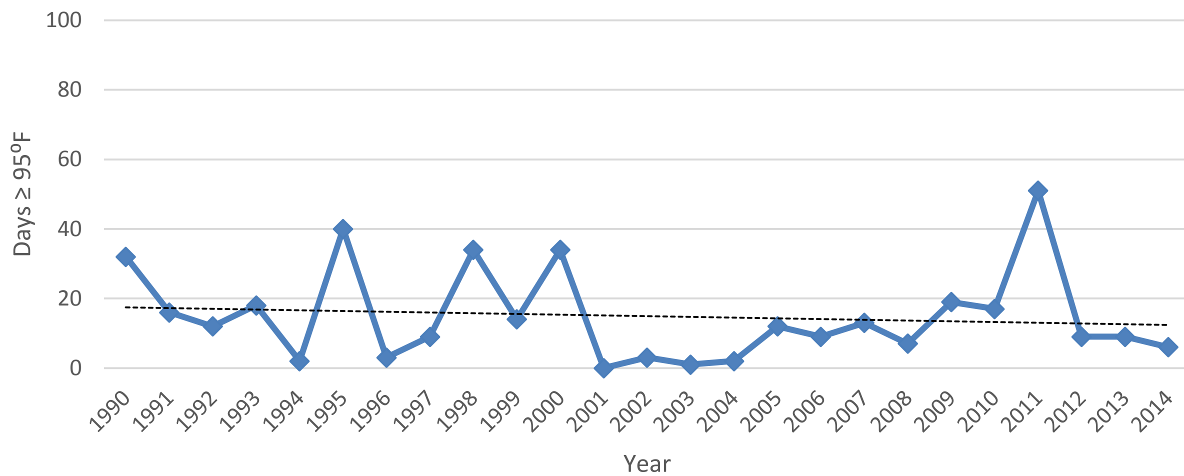
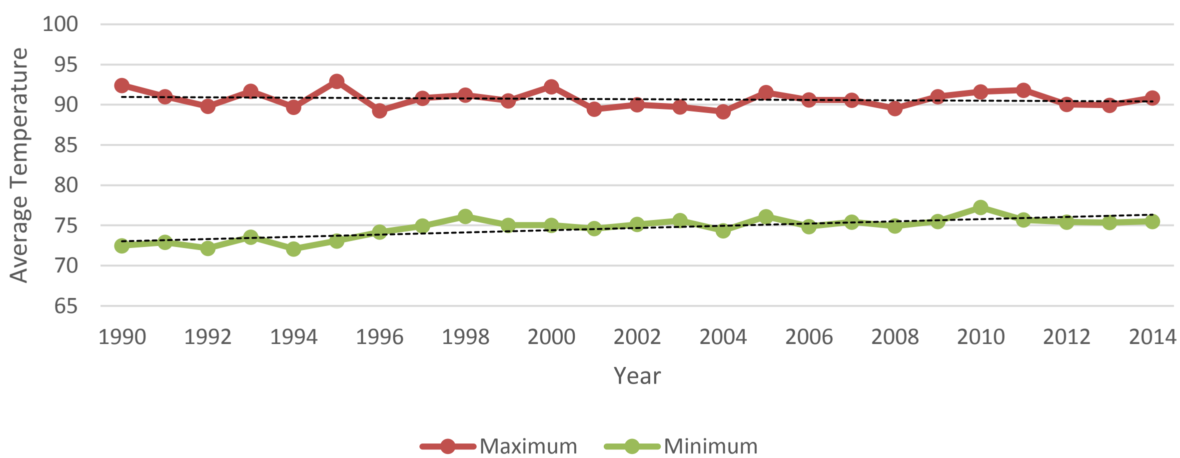
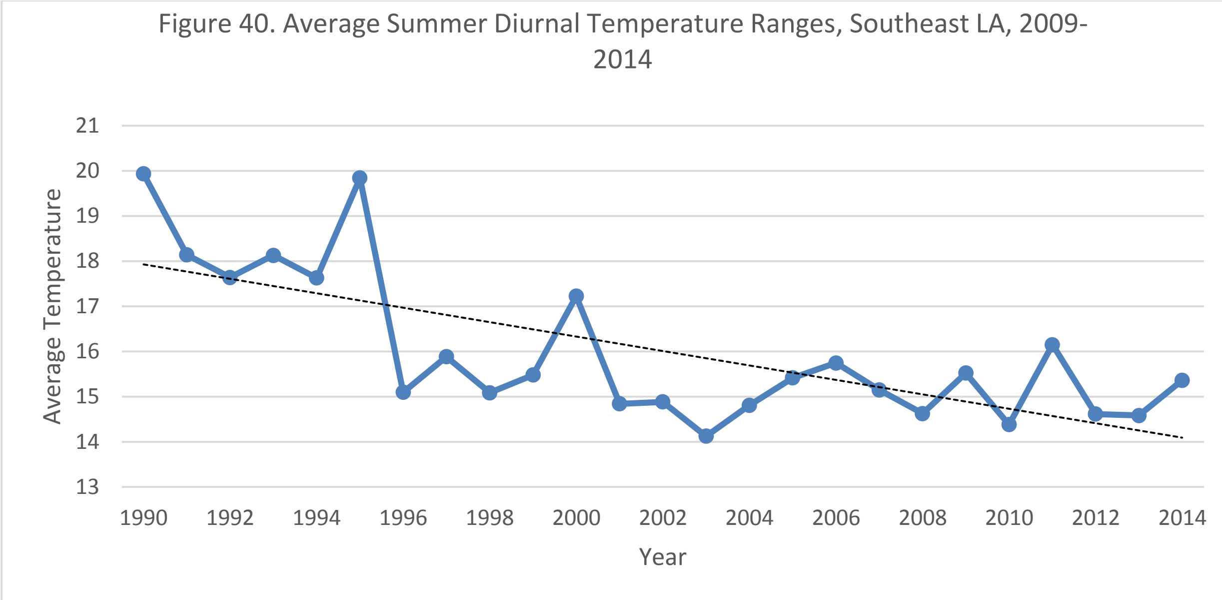


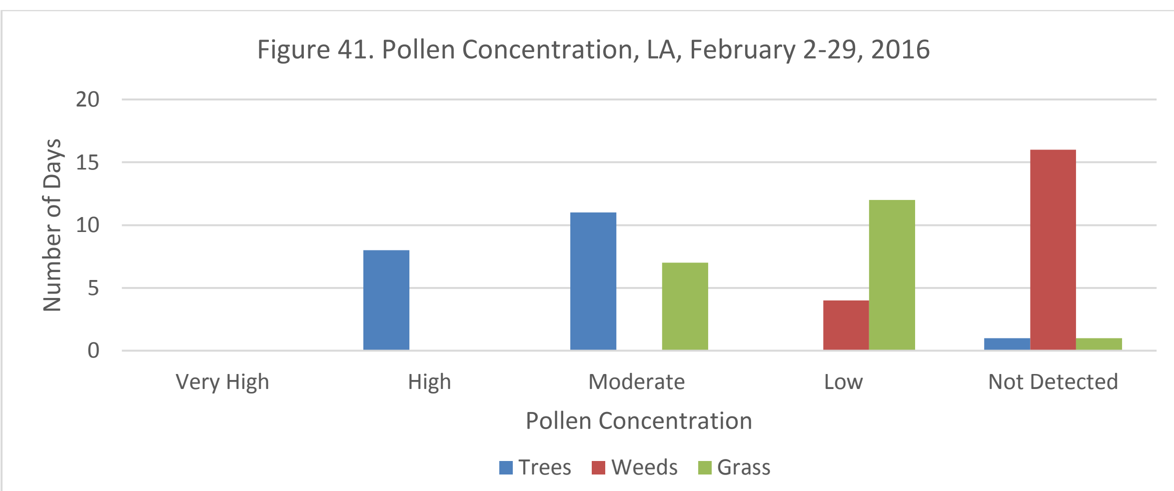
Figure 39. Average Summer Temperatures, Southeast LA, 2009-2014





Pollen

Increased pollen production and season length, changes in type, and increased allergenicity have been linked to climate change (Council of State and Territorial Epidemiologists, 2013e). Pollen and its interaction with other respiratory triggers, in particular air pollution, can adversely influence health outcomes such as allergies and asthma (Levetin & Van de Water, 2008; Shea, Truckner, Weber , & Peden, 2008). The indicator uses data from stations that are a part of the National Allergy Bureau (NAB). The LSU Health Sciences Center in New Orleans operates the only NAB station in Louisiana, which is located in an urban area of New Orleans. The station is new, having only started data collection on February, 2016, and pollen counts for trees, weeds, and grass are obtained only on weekdays (M-F). Figure 41 displays the data obtained for February 2016. Tree pollen was detected in high to moderate concentrations, and grass pollen was detected in moderate to low levels for most of February (19 days). Weed pollen was only detected in low concentrations for 4 days of the month, and not detected at all the rest of the month.



Wildfires

The duration and intensity of wildfires season in the western U.S. appears to be increasing as temperatures increase and the availability of moisture decreases (Council of State and Territorial Epidemiologists, 2013d;

Westerling & Bryant, 2008). Wet conditions during the growing season promote the growth of wildfire fuel in the form of vegetation (especially grasses), and dry conditions just before and during wildfire season increase the flammability of vegetation. Aside monetary losses, human health can also be adversely affected by wildfires as wood smoke has high levels of particulate matter and toxins (Council of State and Territorial Epidemiologists, 2013d). Wildland fire is defined as an unwanted fire where the objective is to put the fire out, compared to a controlled fire that is intentionally started. The state level data are taken from Situation Reports submitted by individual agencies within states, such as Fish and Wildlife Service, National Park Service, and United States Forest Service (Council of State and Territorial Epidemiologists, 2013d).

Figure 42 displays the number of wildland fires that occurred in Louisiana from 2002-2014. There was no significant trend in the number of fires over time. Figure 43 shows the number and percentage of acres in the state affected by wildland fires. In general, the number of acres affected by wildland fires correlated to the number of fires occurring each year. However, while the number of fires remained level from 2012-2014, the number of acres affected by those fires gradually increased from 11,088 acres in 2012 to 25,337 acres in 2014. Less than 0.2% of the total acreage of Louisiana was affected by wildfires from 2002-2014.

Figure 42. Number of Wildland Fires, LA, 2002-2014

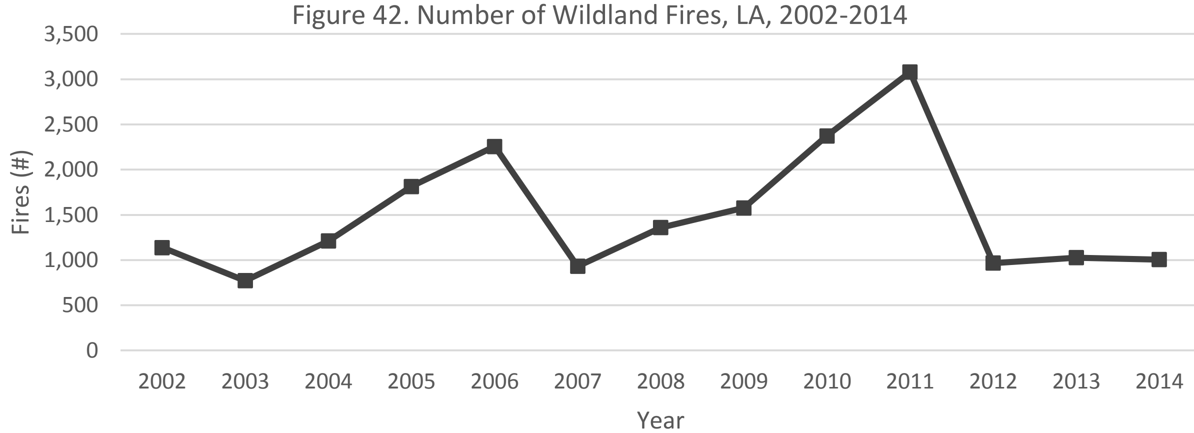
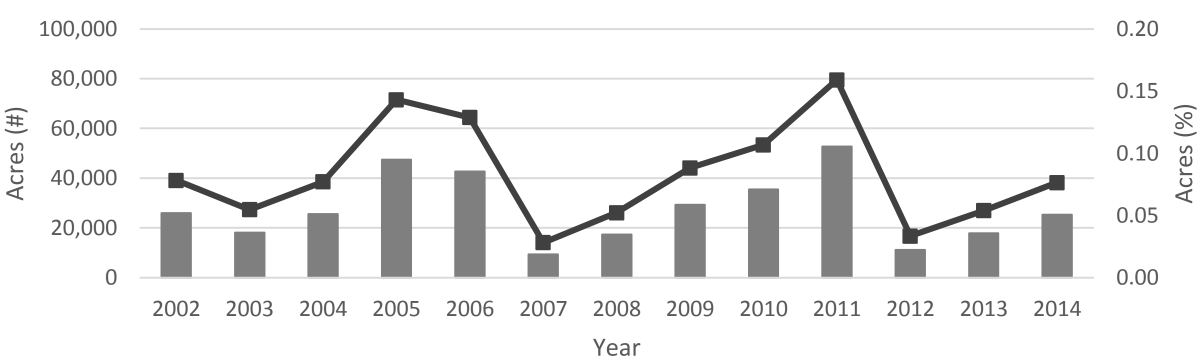


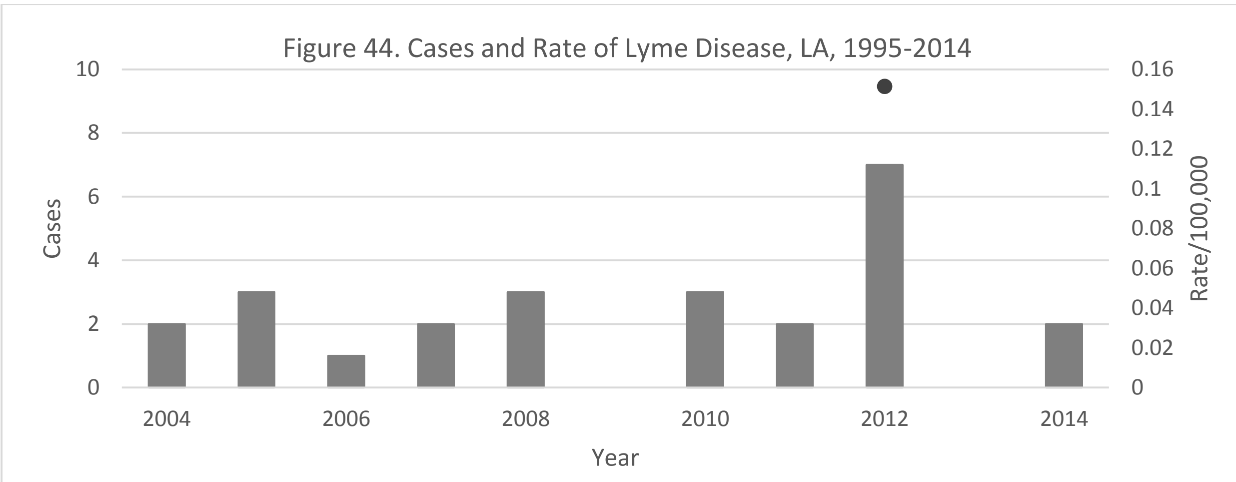
Figure 43. Number and Percentage of Acres Affected by Wildland Fires, LA, 2002-2014



Health Outcome Indicators:

Human cases of Lyme disease

Lyme disease is caused by the bacterium *Borrelia burgdorferi* and is transmitted to humans through the bite of infected blacklegged ticks, *Ixodes scapularis.* The ticks depend on warm, moist environments to survive. Therefore, climate changes may have a significant impact on disease transmission, and the spread of Lyme disease could be used for early detection of climate changes (Council of State and Territorial Epidemiologists, 2013b). While blacklegged ticks exist in the southern U.S., their feeding habits in this region make them much less likely to maintain, sustain, and transmit Lyme disease. According to one study, climate change is predicted to cause an overall 213% increase in suitable vector habitat by the year 2080; however, vector habitat is expected to expand into the Central U.S. and Canada while retracting in the Southern U.S. (Brownstein, Holford, & Fish, 2005). Figure 44 displays the number and rate of Lyme disease cases in Louisiana for 2004-2014. The number of cases was less than 10 each year. There were no reported cases of Lyme disease in 2009 or 2013. The average number of cases for the period of observation is 2.27. Because many years had fewer than 5 cases, the rate of Lyme disease could only be calculated for 2012. The 2012 rate of 0.15 cases/100,000 residents is very low compared to that of NE states (Centers for Disease Control and Prevention, 2015).



Human cases of West Nile Virus (WNV)

West Nile Virus (WNV) was first detected in the United States in 1999 in New York, and the first human case in Louisiana was reported in 2001 in Jefferson Parish. In 2002, Louisiana experienced an epidemic of 204 cases of West Nile Virus neuroinvasive diseases (WN-NID) (Louisiana Department of Health and Hospitals, Office of Public Health, Infectious Epidemiology Section, 2012). Surveillance for WNV was initiated in Louisiana in the spring of 2000 by the Louisiana Department of Health and Hospitals, Office of Public Health, Infectious Disease Epidemiology Section. WNV is considered endemic to all parts of Louisiana and persons of all ages are considered equally susceptible to infection. The majority of all persons infected and immunocompetent are completely asymptomatic (80-90%). A smaller proportion of persons (10-20%) present with influenza-like illness with abrupt onset of fever. A minority of people develop a serious neurologic illness such as aseptic meningitis or encephalitis (0.2% younger than 65 years old, 2% older than age 65). About 10% of people who develop neuroinvasive WNV die (Louisiana Department of Health and Hospitals, Office of Public Health, Infectious Disease Epidemiology Section, 2015).

The goal of the surveillance for WNV Infections in humans is to describe the disease burden of the West Nile infection on the human population. Only WN-NID including encephalitis or meningitis are reliably reported. For every WN-NID case there are about 10 cases of fever and about 90 completely asymptomatic infections. Only one percent of the WN-Fever (WN-F) and asymptomatic (WN-PRE) cases are reported. It is important to note that only WN-NID cases are useful for monitoring disease burden and trends in WNV in humans (Louisiana Department of Health and Hospitals, Office of Public Health, Infectious Disease Epidemiology Section, 2015). Table 2 presents the total number of WNV cases by type of clinical presentation as well as the number of deaths due to WNV for the years 2002-2015. There were a total of 976 cases of WN-NID cases and 103 deaths in Louisiana from 2002-2015. 2002 and 2012 had the most cases of WN-NID with 204 and 160, respectively. From 2008-2011 there were 20 or fewer cases per year, with only 6 cases occurring in 2011.

Table 2. Number of Human WNV Cases According to Clinical Presentation by Year, Louisiana, 2002-2015

	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Total
NID	*204*	*101*	*84*	*118*	*91*	*27*	*19*	*11*	*20*	*6*	*160*	*34*	*61*	*40*	***976***
Fever	124	23	24	54	89	13	30	10	7	4	191	20	59	10	**658**
Asymptomatic	0	4	7	16	22	10	9	8	7	2	46	4	20	18	**173**
Deaths	*24*	*7*	*7*	*11*	*9*	*2*	*1*	*0*	*0*	*0*	*21*	*4*	*12*	*5*	***103***
Total	**328**	**128**	**115**	**188**	**202**	**50**	**58**	**29**	**34**	**12**	**397**	**58**	**140**	**68**	

Table 3 displays the number of WN-NID cases occurring by CDC week and year. Weeks where cases were reported are shaded. The most active years for WN-NID in Louisiana were 2002 (204 cases), 2003 (101 cases), 2005 (118 cases), and 2012 (160 cases). There were 20 or fewer cases of WN-NID in 2009-2011. WN-NID in humans typically begins appearing in late June or early July with some cases occurring as late November and in rare cases, December. During the 14-year period of observation, there was an uptick in cases beginning in mid-July that reached a peak in August and began trending down by mid-September (see Total column of Table 3).

Table 3. Number of West Nile Virus Neuroinvasive Disease Cases by CDC Week, Louisiana, 2002-2015

Month/Week		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Jan		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Feb		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
March		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
April		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
May		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
June	**22**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	24	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
	25	**2**	**2**	0	0	0	0	0	**1**	0	0	**1**	0	0	0	**6**
July	**26**	**11**	**0**	0	0	**1**	0	0	**1**	0	0	**1**	0	0	**1**	**15**
	27	**6**	**3**	**3**	**4**	**1**	0	0	**2**	**3**	0	**3**	0	0	**1**	**26**
	28	**9**	**5**	**2**	**5**	**4**	0	0	**0**	**0**	**1**	**15**	**1**	**3**	**2**	**47**
	29	**23**	**5**	**2**	**13**	**5**	0	0	**1**	**1**	**1**	**11**	**0**	**7**	**1**	**70**
August	**30**	**23**	**8**	**8**	**8**	**6**	0	**2**	**1**	**2**	**0**	**13**	**1**	**9**	**2**	**83**
	31	**21**	**10**	**5**	**21**	**7**	**1**	**1**	**0**	**0**	**0**	**17**	**3**	**3**	**5**	**94**
	32	**24**	**7**	**15**	**11**	**14**	**3**	**2**	**1**	**1**	**1**	**18**	**3**	**4**	**4**	**108**
	33	**21**	**8**	**7**	**9**	**13**	**2**	**1**	**2**	**1**	**0**	**16**	**7**	**9**	**4**	**100**
	34	**14**	**6**	**3**	**8**	**7**	**2**	**3**	**1**	**2**	**0**	**14**	**6**	**6**	**5**	**77**
September	**35**	**8**	**6**	**5**	**6**	**6**	**5**	**3**	**0**	**3**	**1**	**12**	**2**	**3**	**5**	**65**
	36	**13**	**4**	**5**	**8**	**9**	**3**	**2**	**0**	**1**	**1**	**4**	**2**	**8**	**1**	**61**
	37	**8**	**9**	**3**	**9**	**6**	**3**	**0**	**1**	**2**	**1**	**7**	**3**	**2**	**4**	**58**
	38	**6**	**4**	**4**	**2**	**3**	**1**	**0**	0	**1**	0	**4**	**0**	**4**	**0**	**29**
	39	**3**	**2**	**5**	**4**	**4**	**1**	**0**	0	**0**	0	**4**	**1**	**2**	**1**	**27**
October	**40**	**3**	**4**	**5**	**4**	**1**	**3**	**3**	0	**1**	0	**7**	**3**	**1**	**0**	**35**
	41	**3**	**2**	**4**	**3**	**1**	**0**	**0**	0	**0**	0	**2**	**1**	0	**0**	**16**
	42	**3**	**1**	**2**	**3**	**1**	**0**	**0**	0	**0**	0	**1**	**1**	0	**3**	**15**
	43	**0**	**2**	**0**	0	**0**	**3**	**0**	0	**0**	0	**3**	0	0	**0**	**8**
	44	**0**	**4**	**0**	0	**1**	0	**0**	0	**0**	0	**3**	0	0	**0**	**8**

Table 3. Number of West Nile Virus Neuroinvasive Disease Cases by CDC Week, Louisiana, 2002-2015																
Month/Week		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Total**
November	**45**	0	2	2	0	0	0	1	0	0	0	0	0	0	0	5
	46	0	1	1	0	0	0	0	0	0	0	1	0	0	0	3
	47	1	1	2	0	1	0	1	0	0	0	1	0	0	1	8
	48	0	2	1	0	0	0	0	0	2	0	1	0	0	0	6
December	**49**	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3
	50	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NID Total		204	101	84	118	91	27	19	11	20	6	160	34	61	40	

Table 4 displays the number of Louisiana WN-NID cases by parish and Louisiana Department of Health and Hospitals (LDHH) Administrative Region. Figure 45 displays the average annual number of WN-NID cases per capita by LDHH administrative region for 2002-2015. Figure 46 is a map of Louisiana showing the nine LDHH Administrative Regions. As shown in Table 4, from 2002-2015, Region 2 (Capital Area) and Region 9 (Northshore Area) reported the most WN-NID cases with 197 and 192, respectively. Region 7 also reported a lot of cases relative to other regions (181 cases). Region 3 (South Central Louisiana) reported the fewest with 25 cases.

- *Region 1 (Greater New Orleans Area*): most years had 5 or fewer reported cases of WN-NID; several years had no reported cases. The most cases reported in this region was 34 in 2002 followed by 25 in 2015. Other notable years were 2005 and 2006 with 13 and 20 reported cases of WN-NID, respectively. Of the 4 parishes in this region, Jefferson Parish reported the most cases (60) from 2002-2015, followed by Orleans Parish (47); there were no cases reported in Plaquemines Parish.
- *Region 2 (Capital Area*): the most active year was 2002 with 55 cases of WN-NID, followed by the years 2004, 2005, 2012, and 2013 which had 25, 24, 23, and 28 cases, respectively. All other years had less than 20 reported cases, with 3 years having no reported cases. Of the 7 parishes making up Region 2, East Baton Rouge Parish reported the vast majority of cases (135) followed by Ascension Parish (33).
- *Region 3, (South Central Louisiana)*: there were very few cases of WN-NID with 2003 having the most reported cases with 7, followed by 6 reported cases in 2014. There were 6 years where there were no reported cases of WN-NID. Of the 7 parishes comprising this region, Lafourche Parish reported the most cases (10) from 2002-2015.
- *Region 4 (Acadiana):* very few cases of WN-NID. The most cases reported was 10 in 2013, followed by 8 in 2002. There were 4 years where there were no reported cases of WN-NID. For all other years 6 or fewer cases were reported. Of the 7 parishes that make up Acadiana, Lafayette Parish reported the most cases, 19, from 2002-2015, followed by Iberia Parish with 11 cases.
- *Region 5 (Southwest Louisiana):* there were relatively few reported cases of WN-NID, with the most cases, 10, reported in 2012, followed by 8 cases in 2002. For all other years, 5 or fewer cases were reported, and in 6 of those years one or no cases were reported. Of the 5 parishes that make of the Southwest region of the state, Beauregard Parish reported 31 cases from 2002-2015; all other parishes reported 5 or fewer cases during this time period. There were no reported cases from Cameron Parish during the observation period.
- *Region 6 (Central Louisiana):* 19 was the highest number of reported WN-NID cases in a particular year (2002 and 2012). There were 11 reported cases in 2006, all other years had eight or fewer reported cases, with no reported cases in 2010 or 2014. Of the 8 parishes that make up Central Louisiana, Rapides Parish reported the most cases, 63, and LaSalle Parish reported no cases from 2002-2015.

- *Region 7 (Northwest Louisiana):* 49 cases of WN-NID were reported in 2003, followed by 35 cases in 2012, and 24 cases in 2005. Less than 10 cases were reported for eight of the observation years. There were two years of no reported cases, 2011 and 2013. Of the 9 parishes that make up the region, Caddo parish reported 121 cases, and Bossier Parish reported 37 cases from 2002-2015. All other parishes in the region reported seven or fewer cases.
- *Region 8 (Northeast Louisiana):* highest number of cases reported in any year was 18 in 2005, followed by 17 in 2013, and 14 in 2004. There were only 2-3 cases reported per year from 2006-2088 and no reported cases of WN-NID from 2009-2011. Of the 12 parishes that make up the region, Ouachita Parish reported the highest number of cases, 58, from 2002-2015. All other parishes reported 7 or less cases during this time period, with no cases reported in East Carroll and Tensas Parishes.
- *Region 9 (Northshore Area):* there were 57 reported cases of WN-NID in 2002. This high was followed by 31 reported cases in 2012, 25 cases in 2006, and 21 cases in 2005. There were five or fewer cases reported in 2007, 2010-2011, and 2013-2015. Of the 5 parishes that make up this region of the state, St. Tammany Parish had the most reported cases, 72, from 2002-2015. Tangipahoa Parish and Livingston Parish had nearly the same number of cases reported during this time period, 46 and 47, respectively.

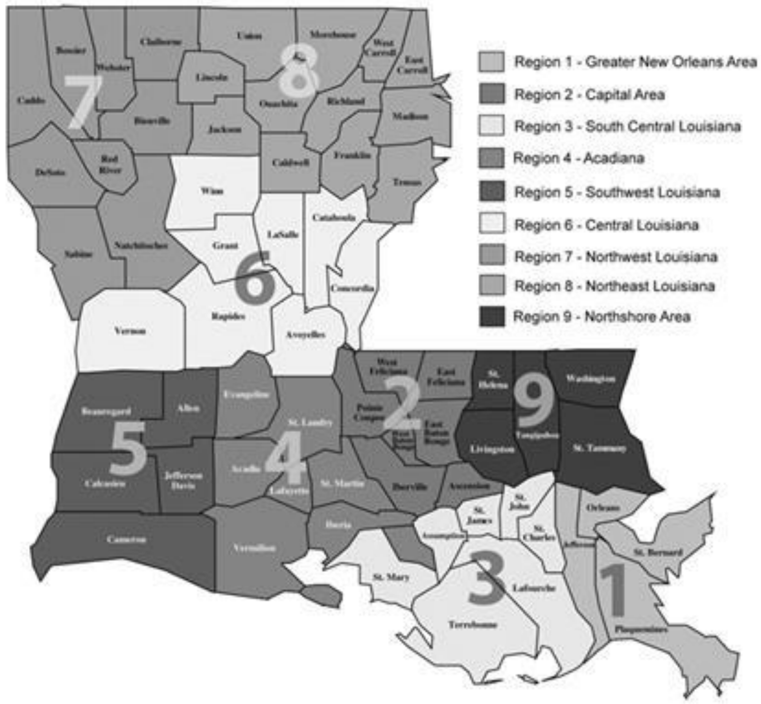
Table 4. Number of WNV-Neuroinvasive Disease Cases by Parish, Louisiana, 2002-2015

Reg	Parish	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Parish Total
1	Jefferson	24	3	1	6	8	2	2	0	0	0	13	0	0	1	60
1	Orleans	10	2	1	6	12	2	2	0	0	0	11	0	0	1	47
1	Plaquemines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	St Bernard	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2
1	Total	34	5	2	13	20	4	4	0	0	0	25	0	0	2	109
2	Ascension	6	2	1	3	10	0	0	0	2	0	3	0	4	2	33
2	E Baton Rouge	37	1	22	17	6	0	0	2	9	0	17	0	21	3	135
2	E Feliciana	2	1	1	0	0	0	0	0	0	0	2	0	0	0	6
2	Iberville	2	0	0	2	0	0	0	0	0	0	0	0	1	1	6
2	Pointe Coupee	6	0	0	0	0	0	0	0	0	0	0	0	2	1	9
2	W Baton Rouge	2	0	1	2	1	0	0	0	0	0	0	0	0	0	6
2	W. Feliciana	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
2	Total	55	4	25	24	16	0	1	2	11	0	23	0	28	7	197
3	Assumption	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
3	Lafourche	0	2	0	1	1	0	0	0	0	0	1	0	4	1	10
3	St Charles	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2
3	St James	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	St John	2	0	0	0	0	1	0	0	0	0	0	0	0	0	3
3	St Mary	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
3	Terrebonne	0	3	0	0	0	0	0	0	0	0	1	0	1	0	5
3	Total	4	7	0	1	2	1	0	0	0	0	3	0	6	1	25
4	Acadia	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
4	Evangeline	1	0	1	0	0	1	0	0	0	0	0	0	0	0	3
4	Iberia	2	1	0	4	0	0	0	0	3	0	1	0	0	0	11
4	Lafayette	4	0	1	1	1	1	0	0	0	0	2	9	0	0	19
4	St Landry	1	0	3	0	0	0	0	0	0	0	0	0	0	2	6
4	St Martin	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
4	Vermillion	0	0	0	0	1	0	0	0	2	0	0	0	0	0	3
4	Total	8	1	5	6	2	2	0	0	5	0	4	10	0	3	46
5	Allen	0	0	0	0	0	0	0	1	0	0	1	0	0	0	2
5	Beauregard	0	0	1	1	0	1	0	0	1	0	1	0	0	0	5

Table 4. Number of WNV-Neuroinvasive Disease Cases by Parish, Louisiana, 2002-2015

Reg	Parish	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Parish Total
5	Calcasieu	8	1	3	2	5	0	1	0	0	2	8	1	0	0	31
5	Cameron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Jefferson Davis	0	1	1	0	0	0	0	0	0	0	0	0	0	3	5
5	Total	8	2	5	3	5	1	1	1	1	2	10	1	0	3	43
6	Avoyelles	2	0	0	0	1	1	1	0	0	0	1	0	0	1	7
6	Catahoula	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
6	Concordia	1	0	0	0	1	1	0	0	0	0	2	0	0	0	5
6	Grant	1	0	0	0	0	0	0	0	0	0	3	0	0	0	4
6	Rapides	14	2	8	7	7	2	0	1	0	0	11	4	0	7	63
6	LaSalle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Vernon	0	0	0	0	1	0	0	0	0	1	1	0	0	0	3
6	Winn	1	0	0	1	0	0	0	0	0	0	1	0	0	0	3
6	Total	18	3	8	8	11	4	1	1	0	1	19	4	0	8	87
7	Bienville	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
7	Bossier	3	8	9	6	2	0	0	0	0	0	6	0	2	1	37
7	Caddo	5	38	8	16	3	7	3	1	0	0	19	0	16	5	121
7	Claiborne	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
7	DeSoto	1	1	0	0	0	0	0	0	0	0	3	0	0	0	5
7	Natchitoches	0	1	0	2	0	0	0	0	0	0	2	0	1	0	6
7	Red River	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2
7	Sabine	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
7	Webster	0	0	1	0	1	0	0	0	0	0	4	0	0	1	7
7	Total	10	49	18	24	6	8	3	1	1	0	35	0	19	7	181
8	Caldwell	0	0	1	0	0	0	0	0	0	0	1	3	0	0	5
8	East Carroll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Franklin	0	0	1	1	0	0	0	0	0	0	1	0	1	0	4
8	Jackson	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
8	Lincoln	0	2	0	1	0	0	1	0	0	0	1	0	0	0	5
8	Madison	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2
8	Morehouse	0	2	2	1	0	1	0	0	0	0	1	0	0	0	7
8	Ouachita	6	2	5	15	3	1	1	0	0	0	3	14	2	6	58
8	Richland	2	1	1	0	0	0	0	0	0	0	1	0	0	0	5
8	Tensas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Union	1	1	1	0	0	0	0	0	0	0	1	0	0	0	4
8	West Carroll	0	2	2	0	0	1	0	0	0	0	0	0	0	0	5
9	Total	9	11	14	18	3	3	2	0	0	0	10	17	3	6	96
9	Livingston	12	5	6	11	1	1	1	0	1	0	6	1	2	0	47
9	St Helena	0	2	0	2	0	0	0	0	0	0	2	0	0	0	6
9	St Tammany	27	4	0	3	14	0	3	4	1	1	10	1	2	2	72
9	Tangipahoa	12	6	1	2	6	1	3	1	0	1	12	0	0	1	46
9	Washington	6	2	0	3	4	2	0	1	0	1	1	0	1	0	21
9	Total	57	19	7	21	25	4	7	6	2	3	31	2	5	3	192
1-9	Year Total	204	101	84	118	91	27	19	11	20	6	160	34	61	40	

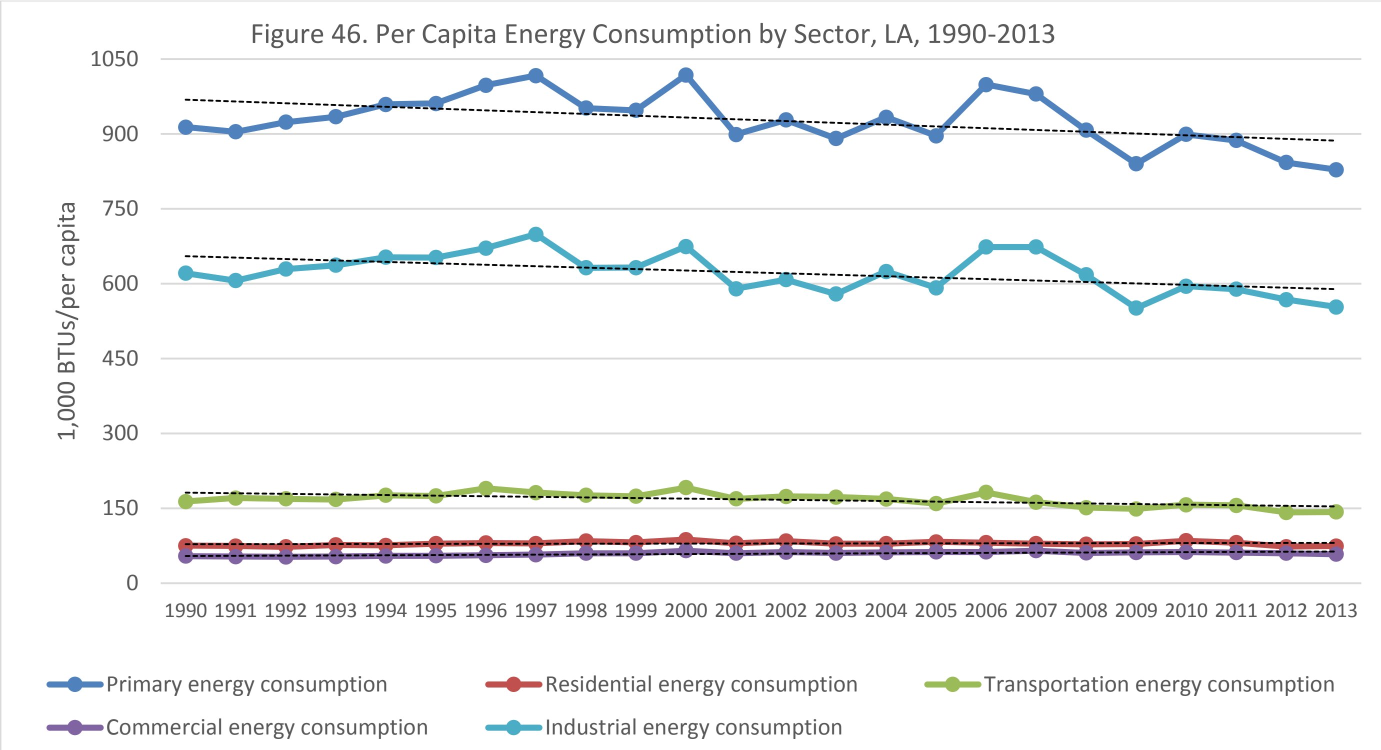
Figure 45. LDHH Administrative Regions



Mitigation Indicators:

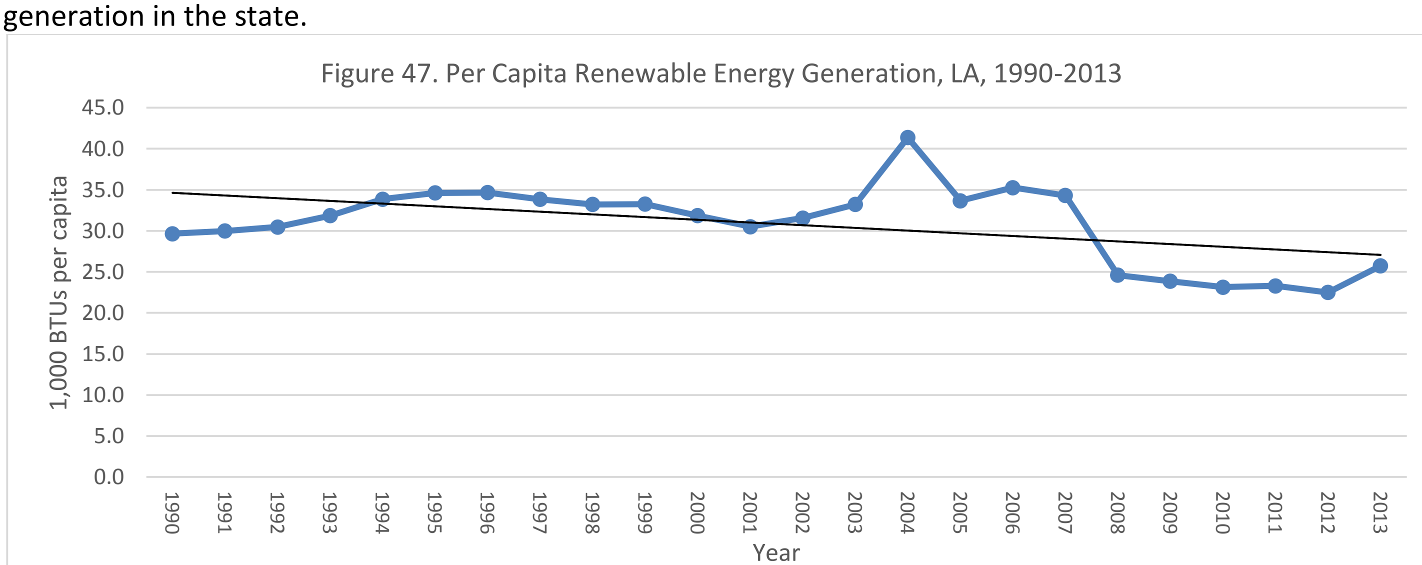
Total energy consumption per capita

When adjusted for state population and employment changes, energy consumption patterns could be an indicator of the impact of climate change mitigation or policy measures on energy efficiency. Energy efficiency measures reduce the demand for energy generated from fossil fuel sources (Council of State and Territorial Epidemiologists, 2015c). The data collected are measured in thousand British Thermal Units (BTUs) from the years 1990-2013, and divided by the state population to obtain a per capita measure. Figure 47 displays the per capita energy consumption in Louisiana by the following sectors: primary, commercial, industrial, residential, and transportation. Primary energy is the form of energy found in nature which has not been transformed in any way, such as the energy found in raw fuels. Primary energy consumption peaked in 2000 (1,018,260 BTUs per capita) and reached its lowest point in 2009 (840,380 BTUs per capita). Compared to other sectors, the industrial sector consumed the most energy with an average of 621,840 BTUs consumed per capita per year, distantly followed by the transportation sector with an average of 167,470 BTUs consumed per capita per year. The commercial sector, on average, consumed the least amount of energy at an average of 59,100 BTUs per capita per year. Results of trend analysis reveal that over time there has been a significant decreasing trend in primary energy consumption (τ=--0.33, p=0.03). Consumption in the industrial and transportation sectors also show a significant decreasing trend in energy consumption (τ=--0.33, p=0.02 and τ=--0.44, p=0.003, respectively). There was a significant increasing trend in energy consumption in the commercial sector (τ=0.53, p=0.0003), while there was no significant change in the consumption of the residential sector.



Renewable energy generation per capita

About 13% of total energy use in the U.S. is in the form of renewable energy, such as hydropower, solar, and wind (U.S. Energy Information Administration, 2015). Increased renewable energy generation from alternative fuel sources could improve air quality as the demand for energy from fossil fuels decreases. An indicator with evidence of increased renewable generation per capita will allow for epidemiological research into the potential health benefits (Council of State and Territorial Epidemiologists, 2015b). Figure 48 displays per capita renewable energy generation in Louisiana for 1990-2013.There was fairly consistent renewable energy generation ranging from approximately 30,000-35,000 BTUs per capita from 1990-2003. In 2004 energy generation peaked at 41,400 BTUs per capita, and from 2005-2007 generation dropped back to around 35,000 BTUs per capita. From 2008-2013 energy generation dropped even further to between 22,000-25,000 BTUs per capita. Trend analysis indicates that over time there has not been a significant change in renewable energy generation in the state.



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